Evaluating the causes and effects of inconsistent construction methodologies on mining projects at Company X, Margaret Shaft

OJ Mosiane

orcid.org/0000-0002-4115-0641

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Supervisor: Mr B Manda

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Student number: 34541616

ABSTRACT

The study was set in the operations management environment with emphasis on mining. Mining companies undertake projects regularly. These are either stay-in-business or mine expansion projects designed to maintain a competitive edge by increasing the exploitable reserves and resources. Mining projects follow a specific and consistent construction methodology (procedures) during execution in order to meet deadlines and expectations. They are a lifeline. However, this is not always the case.

This study was commissioned to study the causes of inconsistent construction methodologies and their associated effects on major mining projects. To do this, one South African mining company (Company X) was selected for the study and one specific shaft (Margaret Shaft) was chosen. Margaret Shaft has one major complex project currently running, valued at R2.7 billion. This project requires the use of EPCM (Engineering Procurement and Construction Management) companies to design and execute on behalf of the owner.

In the past five years, deviations and changes to construction methodologies have occurred at Company X during execution. This was to the detriment of both the project and operations team. These deviations adversely affected the project schedule, costing, and the quality of work done. During the past five-year period, Company X has undertaken in excess of 50 stay in business projects of which 30 suffered extension of time without scope additions.

The study was qualitative in nature and designed to extract perceptions on the causes of inconsistencies to the project construction methodologies through structured interviews. Project construction procedures or methodologies were identified in the literature as:

- Proper SHERG/On-boarding process planning and resourcing
- Construction methodologies, method statement and risk assessment process
- 3rd party interface process effect on construction

- Change management on site

To achieve this, six senior project managers were selected as a sample. These were the most experienced mining experts making key decisions. Scheduled interviews were conducted and the trustworthiness was achieved by ensuring the credibility, authenticity, transferability, dependability, and confirmability of the interviews.

From the interviews, it was found out that the causes of inconsistencies were prolonged on-boarding time, extensive operator training requirements, stringent medical testing failures, lack of right skills, logistical problems, adverse mining ground conditions, delays in local labour requirements among others. The inconsistencies result in major cost overruns and poor production implications to both the contractor and mine.

The study provided recommendations to deal with the causes of inconsistencies that result in delays. These recommendations affect both the client and the contractor.

DECLARATION

I, Onkabetse Jeffrey Mosiane, declare herewith that this work which I herewith submit to the North-West University as partial completion of the requirements set for the MBA degree, is my own work.

OJ Mosiane

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KEYWORDS

Project planning, project costing, project execution method statement, construction and commissioning, project quality management, upfront engineering and design, work breakdown structure.

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ABBREVIATIONS

Abbreviation	Meaning
IRR	Internal Rate of Return
NPV	Net Present Value
SEQ	Site Engineering Query
EPCM	Engineering Procurement and Construction Management
PEMS	Project Execution Method Statement
P&G	Preliminaries and General
WinQS	Measuring software for bill of materials
SPS	Statistical software used for analysis
WBS	Work Breakdown Structure
RAM	Responsibility assignment matrix
MHSA	Mine Health and Safety Act
PMBok	Project Management Body of knowledge
PMO	Project Management Office
SEQ	Site Engineering Querry
OEM	Original Equipment Manufacturer
TEAR	Tender Evaluation and Adjudication Report
TMM	Trackless Mobile Machines
EOT	Extension of Time

CHAPTER 1

Evaluating the causes and effects of inconsistent construction methodologies on mining projects at Company X, Margaret Shaft

CHAPTER 1: INTRODUCTION TO THE RESEARCH

1.1 Introduction

This research is to assess the causes and effects of inconsistent construction methodologies in mining projects at Company X, Margaret Shaft (Complex). It is set up within the Construction Project Management framework in a mining operations environment.

Construction methodology refers to the planned method of construction that takes into account all contractual and legal requirements, construction constraints, risks, and opportunities. It depicts how projects are executed and, this then informs the cost base estimate / budget (Meredith & Mantel, 2012: 283-330). These authors further state that when unforeseeable factors affect construction methodology, the construction becomes inconsistent.

Executing projects within the allocated time and budget without sacrificing quality helps in achieving the objectives that link with the strategic intent of an organisation. In addition, efficient Project Management is one of the key aspects that can provide a competitive advantage to an organization. This is so because mining projects are undertaken with a view to optimise the existing processes, bring about new technology, and reduce operational cost by specifically looking at the major cost drivers in an organisation as well as seeking to optimise those (Meredith & Mantel, 2012: 283-330).

Thus, this research seeks to evaluate the interplay of mining projects, construction methodologies, and determine the causes and effects of inconsistencies during execution of such projects at a selected mine in South Africa.

1.2 Background and Unit of Study

The subject under study is an underground mining entity in South Africa (Company X) with several mining complexes. One of the complexes situated in the Northern Cape Province of South Africa is the Margaret Shaft. The main mineral mined is manganese ore for local and export markets. This complex has several decline and vertical service shafts for taking both employees and material in and out of the underground mine.

Company X undertakes several projects to either expand or stay in business with a view of maintaining a competitive advantage in the market. These projects are critical as they define the life- of-mine by increasing the exploitable reserves and resources.

Underground mining projects include linear development of tunnels / haulages to get to the ore-truck-tip facilities with a view of minimising tramming distances. They also include installation of tip infrastructure, conveyor belts, underground crushers, surface material handling plant, which in turn supplies ore to the load-out station that feeds the outgoing trains to the market.

Company X runs approximately 20-25 stay-in-business projects per year including at least one major project per shaft. A major project has to be financially above R100m, which has an EPCM (Engineering Procurement and Construction Management) appointed to run the project on behalf of the client. In addition, it is classified as well as a growth project requiring expertise that the operations team does not possess. These projects include complex engineering approaches requiring the services of design teams and a suitably qualified site team to manage the construction activities.

Currently, Margaret Shaft or Complex has 23 stay in business projects running. The 23 that are currently running exclude major projects. There is one major (growth) project running at Margaret Shaft in 2021.

Projects go through a number of stages before approval for execution by the board of directors is given. These phases include the following stages (Basson *et al*., 2006:19-40):

- Scoping study
- Pre-feasibility study
- Feasibility study
- Construction
- Close- out

The basis of design and scheduling in the pre-feasibility study and feasibility study appraises the cost base estimate (CBE) which in turn becomes the basis for the business model. A project is approved based on the internal rate of return (IRR), net present value (NPV), and payback period set by the company directors based on a predestined hurdle rate and other indices as per forecasts (Basson *et al*., 2006:161-176).

Construction Methodology documentation are compiled upfront as part of the Project Execution Method Statement (PEMS) which defines how the project will be built. The PEMS is the reference and control document to the schedule, costing, and quality requirements during project execution.

1.2.1 Problem Statement

In the past five years, deviations and changes to construction methodologies have occurred at Company X during execution. This was to the detriment of both the project and operations team. These deviations adversely affected the project schedule, costing, and the quality of work done. A late project results in direct time overruns and this affects the budgets, sales and revenue inflows negatively.

During the past five-year period, Company X has undertaken in excess of 50 stay in business projects of which 30 suffered extension of time without scope additions (Company X, 2021).

Further to this, two expansion projects, one at Margaret Shaft valued at R2.7bn and the other at another shaft valued at R6.7bn are currently underway. The total combined value of the two major projects / expansion projects amounts to R9.4bn.

The study focuses on major projects as variations attracts the biggest cost component compared to stay in business projects which are smaller in scope.

Currently, the project at Margaret shaft is estimated to complete at R2.98bn (10% more than the plan) while the two other major projects are estimated to complete at R7.3bn (9% more than the plan) totalling R10.28bn (9.4% more than budget) due to variations on site that are not attributed to change in scope or additional scope.

Therefore, it is important to evaluate the causes and effects of inconsistent construction methodologies at Company X, Margaret Shaft that lead to prolonged project duration and increases in cost. This study intends to identify the causes and their possible effect on mining projects as perceived by mining experts, and provide possible solutions to mitigate the negative effects. The study focuses primarily on major projects only as their effect is more intense than the small stay in business projects.

1.2.2 Core Research Question

What are the root causes of inconsistent construction methodologies on-site and their related effects on a major project at a mine?

1.2.3 Specific Research Questions

From the core research question, the specific questions are as follows;

a. How can we make the construction method statement and risk assessment process consistent from contract approval to completion of construction activities?
b. How can the 3rd party interface process be handled correctly as not to affect construction?
c. Which ways can the change management on site be handled in a manner that does not affect cost and time?

1.3 Research objectives

The main objective of the research is to explore how inconsistent construction methodologies contribute to the majority of the major projects failing and resulting in time and cost overruns.

1.3.1 Sub Objectives

The sub-objectives to support the main objectives are summarised as follows:

- To assess the causes of prolonged construction methodologies on site
- To explore the effects of project upfront activities on construction commencement
- To enumerate the effects of time and cost of prolonged construction

1.4 Methodology

The methodology involves a literature review in order to understand the academic aspect of the subject. A qualitative interview process follows this on a selected sample from the identified population.

1.5 Literature Survey

The survey intends to identify key performance areas in terms of achieving success in construction methodology, gaining competitive advantage and dealing with causes and effects of inconsistences. Topics such as project design, project life cycles, sustainability, environmental, political and economic factors as well as micro and macro factors will be considered in the consistent construction methodology and discussed in order to give a robust theoretical framework.

In order to conduct a comprehensive literature review, multiple sources will be used during the research process. The sources to be consulted will include:

- Academic journals
- Books
- Internet

- Interviews

1.6 Research Design

The research will use a qualitative design approach with structured interviews to be conducted to obtain data and gain the necessary insight to help answer the research question, thus making it a qualitative study (Kotzé, 2007). A qualitative research approach offers more flexibility when collecting the data necessary for a study. Furthermore, the study will be cross-sectional as the interview and study will take place in a single point in time (Maninder, 2026:2016-264).

1.7 Study Unit, Population and Sample

In research, there is a study unit/subject, the population and the sample. In this research, the subject is the major project at Margaret Shaft.

Secondly, a population refers to the focal group from which the researcher will draw conclusions. It is a sum of the persons, events, organization units, or cases with which the specific research problem is concerned (De Vos, 1998:190; Goddard & Melville, 2001:34). The population is the whole workforce at Company X. In total, it is 580 respondents.

A sample is selected from a population. The need for a sample is driven by the impracticality of collecting data from the entire population. Budget and time are constraints to surveying the entire population (Saunders & Lewis, 2009). The participants selected for the interviews are senior and key project executors who make strategic decisions. All the participants have good knowledge in the field of the study and the data that to be collected will prove invaluable towards answering the research question.

The participants are;

- Consultant X Project Manager/ Lead Project Engineer
- Consultant Construction Manager
- Contractor Project Manager/ MD
- Company X Engineer (MHSA, Regulation 2.13.1 Engineering Manager)
- Company X Clerk of Works
- Company Y Project Manager

1.8 Data Collection Process

The data will be collected through scheduled interviews using structured questions. These questions are designed to explore the following constructs that affect construction project management (PMBOK, 2020):

- SHERG/On-boarding process planning and resourcing
- Construction methodologies, method statement and risk assessment process
- 3rd party interface process effect on construction
- Change management on site

The interviews will be recorded by using a mobile device and then later transcribed for analysis.

1.8.1 Reliability of data

Reliability in qualitative research refers to the stability of responses to multiple coders of data sets. It can be enhanced by detailed field notes by using recording devices and by transcribing the digital files (Heala & Twycross, 2015:66).

1.8.2 Validity of Data

Validity is defined as a measure to which a study / concept is measured in a study. It ensures that what was meant to be measured and evaluated is done and that there is no deviation. Trustworthiness is achieved by credibility, authenticity, transferability, dependability, and confirmability in qualitative research. (Heala & Twycross, 2015:66).

1.8.3 Importance and benefits of the proposed study

The study is of vital importance to the mine in that it intends to identify the root causes and inefficiencies in the system that contribute to projects being late and attract more costs. The outcome of the study seeks to inform changes in existing procedures with a view of streamlining construction activities to the benefit of both the project and the mine.

1.9 Delimitations and assumptions

1.9.1 Delimitations (Scope)

The scope will be limited to Margaret Shaft and the projects on this shaft. The criteria of projects to be evaluated will be based on the following;

- Projects to be studied must be over R100m.
- Project must be big enough to have an upfront engineering and design work that requires a professional engineer's input during construction.
- Projects must make use of an EPCM (Engineering, Procurement and Construction Management) Consultant house or at least EP.
- Construction work should be executed by external contractors only.

1.9.2 Assumptions

The following assumptions are to be adopted;

- Project delays due to inadequate designs are minimal and sorted out within 24 hrs of an SEQ being raised.
- Contractor equipment is 80% available and effects of labour inefficiencies due to being off sick are minimal.
- All other external factors such as acts of God and fall of ground are minimal.
- Geology is homogenous for underground projects, with no adverse ground conditions.

1.10 Proposed Chapter Layout

Chapter 1: This chapter introduces the background and problem statement; followed by the aim, research questions and objectives, as well as a summary on the methodology used to conduct the research.

Chapter 2: Literature review

In this chapter, project management and construction methodology is explained followed by a description of a project life cycle. The project life cycle is explained through its stages from conception to project close out. Then literature dwells on the possible causes of project failures and the ways of measuring project success.

Chapter 3: This chapter gives an overview of the research methodology, design, research paradigm selected, and the population and sample selected. It also explains the interview schedule to be used in the qualitative research

Chapter 4: Results

The interviews are transcribed and recorded in this chapter

Chapter 5: Discussion of results

The transcribed results are analysed and discussed in the chapter

Chapter 6: Conclusion and recommendations

The last chapter presents the results from the findings and presents recommendations and conclusions from the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This section details the literature to support the study. It starts by defining project management, construction methodologies before dwelling on project execution and life cycle. The reasons causing project failures are also discussed.

2.2 Project management and construction methodology

A project is a unique, temporary venture, undertaken to achieve planned objectives, which are defined in terms of outputs, outcomes or benefits. A project is usually deemed a success if it achieves the objectives according to the technical acceptance criteria, within an agreed timescale and budget. Time, cost and quality are the building blocks of every project (Stojcetovic, 2013).

Further-on, Project Management is the application of processes, methods, skills, knowledge and experience to achieve specific project objectives according to the project acceptance criteria within the agreed parameters. Project management has final deliverables that are constrained to a finite timescale and budget (Naybor, 2014).

On one hand, Construction Methodology refers to the planned method of construction that takes into account all contractual and legal requirements, constraints, risks and opportunities. It also includes the temporary and permanent works and services required to complete the construction work (PMBOK, 2020)

2.3 Project Success and Project Life Cycle

Project success has been historically defined as a project that meets its objectives under budget and under schedule. This evaluation criterion has remained as the most common measure in many industries. The overall success of projects in South Africa was researched and analyzed by particularly looking at project

maturity and adherence to the PMBOK (Project Management Body of Knowledge) knowledge areas. The study showed that 46% of the projects were successful, 36% were challenged and 18% had failed. (Pretorius *et al*., 2012:6). The definition of a successful, challenged and failed project is explained below:

- **Successful**: A project delivered on time, within budget, within the scope, and complies with the quality requirements. It delivers value and expected returns.
- **Challenged**: A project that is completed, but late, over budget, and does not meet all the quality requirements. It delivers moderate value and fewer returns than expected.
- **Failed**: A project that was never completed does not meet customer requirements, delivers little to no value at all.

The Project Management life cycle is usually broken down into four phases: initiation, planning, execution, and closure. These phases make up the path that takes the project from the beginning to the end.

According to the PMBOK Guide (Project Management Body of Knowledge) by the Project Management Institute (PMI), a project management life cycle consists of five distinct phases that include initiation, planning, execution, monitoring, and closure that combine to turn a project idea into a working product.

Eby (2018) states that a project life cycle is divided into five phases and these stages are as follows;

- Concept and Initiation
- Definition and planning
- Launch or Execution
- Performance and Control
- Project Close out

2.4 Concept and Initiation

This is the first stage of a project. This stage of the project starts with the identification of a gap or business opportunity. Then the strategic intent or effect of the gap of business opportunity on the organization is subsequently evaluated.

During post-high level scoping, concept/s are suggested as possible solutions to the problem or challenge at hand. This is normally referred to as a high-level business case which captures the following as deliverables (Villanovau, 2019);

- A detailed description of the problem or opportunity
- A list of the alternative solutions available
- An analysis of the business benefits, very high-level costs and risks
- A description of the preferred solution
- A high level plan on implementation

A project charter (very high-level definition of the project scope) is defined and signed off by the board or project steering committee. The approval of the project charter at this stage allows the project to spend the approved risk capital in setting up the preliminary team and an office to operate from. A skeleton team is set up in the project management office (PMO) and, this may include consultants (technical and commercial).

A terms-of-reference document detailing the specific responsibilities and roles of all the stakeholders is then drafted and signed off. The responsibilities include a responsibility matrix, an organogram, a communications plan and a risk register among others. A risk register at this stage is very important as it highlights and mitigates all the identified risk factors and thereby shapes the subsequent decisions to be taken (Archibald *et al*., 2012: 10-30).

This stage is normally referred to as the pre-feasibility stage where options are still looked at and weighed against each other to get to the most feasible one. The deliverables for this stage are as follows (Eby, 2018);

- High level workable/ preferred solution

- High level costing at 20-30% accuracy
- High level schedule
- High level risks associated with the chosen solution

Clarizen, (2019) goes further and says deliverables must include a vision document, business justification, feasibility study, scope document, preliminary budget estimate, communication plan and a kick-off meeting. These deliverables are defined as follows;

Table 1: Project deliverables Source: (Clarizen, 2019)

Deliverable	**Description**
Vision document	▪ It sets out high level requirements of a business and who the stakeholders are. It further specifies what the current problem or challenge is and what solution the project will bring about.
Business justification	▪ This document goes into more depth as to what the current situation is costing the company now, in the medium term and long term as well. This details the solution on the table and how this will solve the challenge at hand.
Feasibility study	▪ This section details what costing will be needed in the next stage of the project and what other regulatory requirements need to be complied with, resources, contractors, etc.
Scope statement	▪ This document details what is in the scope and what is not and key stakeholders are aligned. This helps to prevent scope creep in the later stages of the project life.
Preliminary budget	▪ This is a high level budget of what will be needed to see the project through.
Communications plan	▪ This sets out roles and responsibilities and who talks to who about what to prevent confusion. This further clears the authority limits to be used during the project life.
Kick-off meeting	▪ This is an alignment meeting between all stakeholders to manage expectations and start off with the same goal in mind.

Current literature, differs a bit in terms of which document must be given as part of the deliverables at this stage. This will differ from company to company. The naming convention as well differs but the contents of these are the same. For example, the vision document constituents are the same as that entailed in the project charter. It can be deduced that a solution or business justification of a solution including costing and the related governance documents must complete at the end of this phase.

2.5 Definition and Planning

This is the second phase of the project. This phase of planning is the key or most important phase of successful project management. It is called the feasibility study. This phase starts by developing and setting goals and the most popular method for goal setting is S.M.A.R.T (Specific, Measurable, Attainable, Realistic and Timely) (Basson *et al*., 2006:55-68)

Some of the critical inputs are based on giving intelligent estimates with reasonable contingency levels. Estimates can include capital equipment, staffing, direct and indirect costs.

If any of the events or activities are estimated incorrectly or not scheduled correctly, construction will suffer the most in the next stage of the project during execution (Method123, 2018).

The deliverables which are consolidated into the final report are detailed below. It must be noted that all assumptions made in the feasibility study report are also input to the business model which will be used to compute the project profitability and sustainability (Repositorio, 2015). The following are the deliverables under the definition phase of a project;

- Scope statement/ document
- Work breakdown structure (WBS)
- Baseline schedule and Gantt Chart
- Resource Plan
- Cost Management/ Financial Plan
- Procurement Plan

- Communication Plan
- Quality Management Plan
- Risk Management Plan
- Safety management system

2.5.1 Scoping Document

The scoping document summarises the gap or business opportunity, client technical expectations, time and budget estimates. The agreement is entered between the appointed manager and the client or his representative. A project charter is then drafted and be approved by both the client and the sponsor (Malsam, 2018).

In addition, the document includes anti scope exclusions that the project team must not execute. This is very important particularly in brown fields projects so that scope creep can be avoided and to minimize conflict between the project and production team. This document should be accessible to all stakeholders (Project Manager, 2019). In summary, the scoping document must cover the following;

- Project justification: This covers the need for that particular project
- Scope description: A high level document stating what needs to be done and what will be left out including key stakeholders and their expectations
- Business objectives: the benefits that the business will achieve on completion of the project
- Project Deliverables: what the project team will deliver to achieve the business objectives, this can be captured as commissionable systems.
- Project exclusions: what the project team will not be doing as part of the project scope, this includes all battery limits as well.
- Project constraints: All constraints must be listed including but not limited to risks, resources, methodology of doing work, legal compliance changes to legislation and construction calendar.

- Project assumptions: these are assumptions made on constraints that have been identified. These assumptions must also filter through to the basis of costing and scheduling document.

2.5.2 Work Breakdown Structure

The feasibility and scoping project stages result in a proposed solution to address the identified business gap. The solution would then be broken into small portions of work generally known as commissionable systems. A WBS is broken down into levels / tiers for ease of reference (Basson *et al*., 2006:73-79).

A commissionable system (tier 2) normally has work packages (tier 3) and these work packages dictates the procurement plan and how contracting will be carried out. The breaking down of commissionable systems into work packages forms a WBS and is normally presented in a tree format. A WBS is very important in a project as it informs the cost and accounting systems which in turn helps with reporting (Basson *et al*., 2006:78-81).

Furthermore, a WBS can be taken down one level where WBS dictionaries are done to direct future activities in order to form a work package. WBS dictionaries provide detailed descriptions of work to be done per work package and these must be used when obtaining proposals from contractors. These activities are details of what was approved in the scoping document and these are most of the time fed into the overall project schedule (Masterofproject, 2020).

2.5.3 Baseline Schedule and Gantt Chart

According to the PMBOK (2020), a baseline schedule is the planned schedule of the project after its approval by the relevant parties. It is the product of the schedule development process. This schedule is used to measure and monitor the performance of a project: the delivered work at a point in time or over a period of time is compared against the baselined planned work at that time. It sets out how the project will compare with the actual performance against the baseline. A schedule baseline comprises of (at least);

- the documented planned project schedule and

- the approval by the relevant stakeholders.

Furthermore, the detailed components of the schedule baseline may vary among projects (Scott, 2020). However, the essential information reflected in the baseline is usually:

- order of the project activities,
- dependencies between activities
- activity durations
- planned/baselined start and finish dates of activities,
- underlying assumptions and constraints,
- resource requirements, and
- other elements necessary for the schedule planning of the project

As noted by Meredith (2017:72), Research and Development projects have no previous references to use as a base. Therefore, these types of project are difficult to execute as the schedule is purely estimation and schedule optimization occurs during execution. On other projects, scheduling is guided by using previous experience and information from previous projects (Scott, 2020).

A Gantt chart is then developed to assist with managing float, critical path management, opportunities for early starts, and late finishes during project execution. Other organizations prefer the project manager to disclose off his float to the sponsor well in advance (Scott, 2020).

According to Investopedia (2020), A Gantt chart essentially helps in scheduling, managing, and monitoring specific tasks and resources in a project. The chart shows the project timeline, which includes scheduled and completed work over a period (Investopedia, 2020)

2.5.4 Resource Plan

As articulated by Dopson (2021), resource planning is a process of allocating tasks to team members based on their capacity, skill sets, and the best fit for the job. It maximizes efficiency by helping teams to manage their utilization rates, track capacity, and monitor progress, to keep projects on budget and work on

track. Resource planning helps business owners make the most of their available resources,

2.5.5 Cost Management Plan

A cost management plan is a process of establishing policies, procedures, documentation for planning, managing, expanding in order to controll project costs (Master Of project, 2020).

Firstly, costs are allocated as per WBS. Secondly, procedures must be put in place to manage the movement of costs between WBS areas and these movements approved accordingly. Furthermore, the procedures must cover budget shortfalls, changes in scope, instructions given on site on out of scope items, approval authority, forecasting against business plan, and cost management and reporting (Basson *et al*., 2006:161-184).

In addition, a change management procedure must be drafted and approved to ensure that if there is any change on-site, this change is captured and filtered into the register and the cost management system as well. The authority limits of these changes must be clearly defined to ensure that the site project manager does not approve changes that are over an approved limit (Master Of Project, 2020).

Cost management plans should also include how and when contractors' invoices should be submitted, adjudicated by the project engineer and the QS and eventually processed for payment. In essence, a costing calendar, approved by the project manager and the finance manager should be in place.

As a component of the cost plan, monthly cost meetings should be held with all the stakeholders. In these meetings, actual financial performance is compared against the budget and actual progress achieved and variances explained and mitigated as well.

Additional meetings should be held to roll up the costs and to look at the cumulative effect of all packages against the business plan expenditure and adjustments effected when required (PM Tips, 2019).

2.5.7 Communication Plan

A project communications plan identifies how important information is communicated to all stakeholders throughout the project. A communication plan must be set up during the scoping phase and this should include a responsibility assignment matrix (RAM).

This plan must be reviewed at least yearly particularly on brown-fields projects where there is constant change. In addition, the plan must show reporting structures and aligned with the approved project charter (Teamgantt, 2018).

There has to be a clear distinction between legal reporting as per the MHSA guidelines and functional reporting for day-to-day project work. According to Luchen (2020), emergency reporting must also be catered for all unplanned incidents that need quick approvals. The following guidelines must be adhered to in setting up a project communication plan (Lucidchart, 2019);

- Choose a format that will make it easy to give feedback
- Set a communication goal
- Identify stakeholders that must receive communication
- Identify methods of communication with the identified stakeholders
- Determine the frequency of communication

It is of vital importance that a communication plan is in place. A communication plan matters because effective communication is critical to a project's success. It clarifies the relationships between audiences, messages, channels, activities, and materials. Poor communication leads to delays which in turn attract costs leading to project failure.

2.5.8 Quality Management Plan

A quality management plan is put in place to ensure that there is quality assurance and quality control (QA/QC) before and during project execution (Ray, 2018). The quality management plan provides guidance on how quality will be ensured on the project through design reviews, documentation, and other protocols (Chron Contributor, 2020). It determines the scope of the parameters to

be measured, what metrics will define whether the project is successful from beginning to end.

A quality management plan is normally derived from the PEMS and includes systems such a quality control plan (QCP). This allows the team to create hold points or verification points as the project continues with a view of ensuring that the best quality product is delivered. All inspections should be follow the approved project specification and IFC drawings for individual trades (mechanical, electrical, instrumentation, mining, etc.) read in conjunction with mine specific standards as approved by the standards committee (Ray, 2018).

Quality procedures must cater for both off site and on site activities and care must be taken to ensure that responsibilities do not overlap (Luchen, 2020).

2.5.9 Risk Management Plan

Risk management is important during project initiation, planning, and execution; well-managed risks significantly increase the likelihood of project success. The plan contributes to project success by establishing all internal and external risks and mitigating them accordingly.

This plan typically includes the identified risks, probability of occurrence, severity of impact and mitigating actions. Low risk events usually have little or no impact on cost, schedule or performance while high risk events can have significant material impact on the project (Chron Contributor, 2020).

The project should have an overall risk register of all possible circumstances. The risk register should be reviewed regularly as per project procedure to ensure that any new risk is catered for as the project continues (Basson *et al*., 2006:19-40).

All major risks identified should be mitigated through an elimination, a preventative or tolerating strategy and a contingency plan in place if the risk materialises (Ray, 2021).

There are different ways of approaching risk management. The probability approach has been used over the years in the mining industry. This approach looks at risks related to budget, schedule and performance with a view of identifying, categorizing, prioritizing, and planning for all risks before they materialize (Ray, 2021).

The process is as shown below in figure 2. It is very important to ensure that each identified risk is allocated a champion who must continuously give feedback during project execution (Ray, 2021).

Figure 1: Risk management framework Source: (Ray, 2021)

In addition, the inclusion of the high risk elements into the baseline is important in that the schedule becomes realistic and can be executed safely. A complete safety management system must be in place and approved by the legal appointees. This system must be adequately resourced to ensure better outcomes and prevent stoppages during construction (Scavetta, 2019).

2.5.10 Safety Management Plan

The safety plan or file is a written document outlining all of the health and safety information a worker needs to know about working safely during the construction phase of the project. This safety file is an integral part of the SHERQ system. It protects the employer from criminal liability and proves compliance with the

related legislation, in this case, the MHSA which references the OHSA under section 80 of the act (Stephan, 2019).

The implementation plan of the safety management plan must include the following as a minimum (Jemena, 2019);

- Legal compliance: legal structure to comply with the related Act
- Communication plan: How is normal communication internal and external handled, protocol to be followed using the committees as guided by the related legislation.
- Training and competency: what are the basic requirements for personnel to comply with the related legislation.
- Safe work systems: System that will be used to identify and manage risk during project implementation
- Incident management: How are incidents reported, investigated, and learning captured to prevent re-occurrence
- Fitness, health, and hygiene plan: What basic minimum health and fitness test the employees will be subjected to prior to being engaged for construction work. This further includes hygiene particularly now with Covid-19 at workplaces and how this will be dealt with.
- Plant and equipment compliance: to comply with the related MHSA or MCOP, what equipment must be fitted with before they are brought into the mine
- Emergency planning and response: what will be put in place in case of an emergency at the workplace and we will react to this. This includes incidents such as fire, fall of ground, fatalities, etc
- Document and record management system: A system must be in place to identify hazards/ risks, record them and assign them to an individual, resolve these as per the requirement of the related legislation and keep a record that they have been closed out.
- Auditing, review and continuous improvement: This allows for external audits with a view of identifying the gaps in the set system and to provide for continuous improvement when new rules are being promulgated.

The plan must always comply with the strategic intent of the organization. This will give guidance in achieving the medium and long term goals. The plan must further emphasize the value system and culture of the company (IAAC-AEIC, 2017).

2.6 Project Execution or Launch

The execution phase of the project lifecycle is when the work is done. In this phase, the plan is implemented according to the scope, schedule, quality and safety plan.

This is the phase where full teams are set up, resources are assigned (contractors, consultants), procurement done, project tracking systems, change management, legal compliance systems put in place. The successful implementation of a project is highly dependent on proper upfront scoping as this cascades into the schedule, methodology of doing work, quality control plans, and costing as far as time is concerned (Mattheys, 2019).

2.7 Performance and Control

This phase is about measuring project performance, progress and ensuring that all events are as per the original plan / scope. This includes constant updating of the schedule against the baseline, achieved cash flow against the plan (S-curves), and ensuring that construction is done according to design and the approved quality management system (Jackson, 2020).

2.8 Project Close-Out

This phase of the project involves consolidating all the stages mentioned above and producing a report that includes the final account, technical closeout, financial close out, lessons learnt and demobilization of the teams and resources. This information is archived for future reference in the organization (Vaitor, 2019).

2.9 Causes of Project Failures

A successful project is one completed on time and within budget and having attained the technical criteria. When a project fails, it is typically due to conflicts and issues that cause cost overruns and delays in the schedule (Jones, 2021).

There is a lot of research on why construction projects fail. According to the Herald Online (2011), one of the major causes of project failures is poor planning. Most of the time, the problem is due to inadequate or no planning at all. The team simply tries to "wing it", to do the work without doing any planning at all.

As per Shahhosseinia *et al.,* (2018), the common causes of project failure can be grouped into three main categories and these are: (1) people factors, (2) project process factors; and (3) project communications factors. On one hand, the Project Management Institute (PMI, 2020) identified seven major contributors of project failures. They highlighted two as the most common and these are:

- Failure to have a consistent methodology for planning and executing projects and
- Excluding the customer at the beginning of the project and failure to continually engage the customer along the stages of the project.

Lawrence (2004:4), in his studies identified the following as the major causes of project failures

- Poor initial planning
- Inadequate client team consultation
- Project team dynamics
- Client team relationship management
- Inadequate resourcing
- Lack of dependency understanding
- Poor change management

Malsam (2018) surmised and argued that ‘75% of the abovementioned failure drivers refers to scope definition and this is known to the industry at large but one wonders why so we still have inadequate scope definition on major projects with all the available information and research done’ . The above-mentioned contributors are discussed below;

2.9.1 Poor initial planning

Poor planning leads to poor execution. The process should start by the meticulous review and full understanding of the plans, specifications, scope of work, and client expectations. This planning involves working with the client, architect, subcontractors, and suppliers to establish construction schedules and project milestones (Jones, 2021).

Other poor planning indicators include practices such as combining stages such as carrying out construction and engineering designs concurrently. Despite this being a precursor for failure, there are proponents of this approach who believe that it saves time during construction as this gives the project an early start.
Proper project planning is exemplified in figure 2 below;

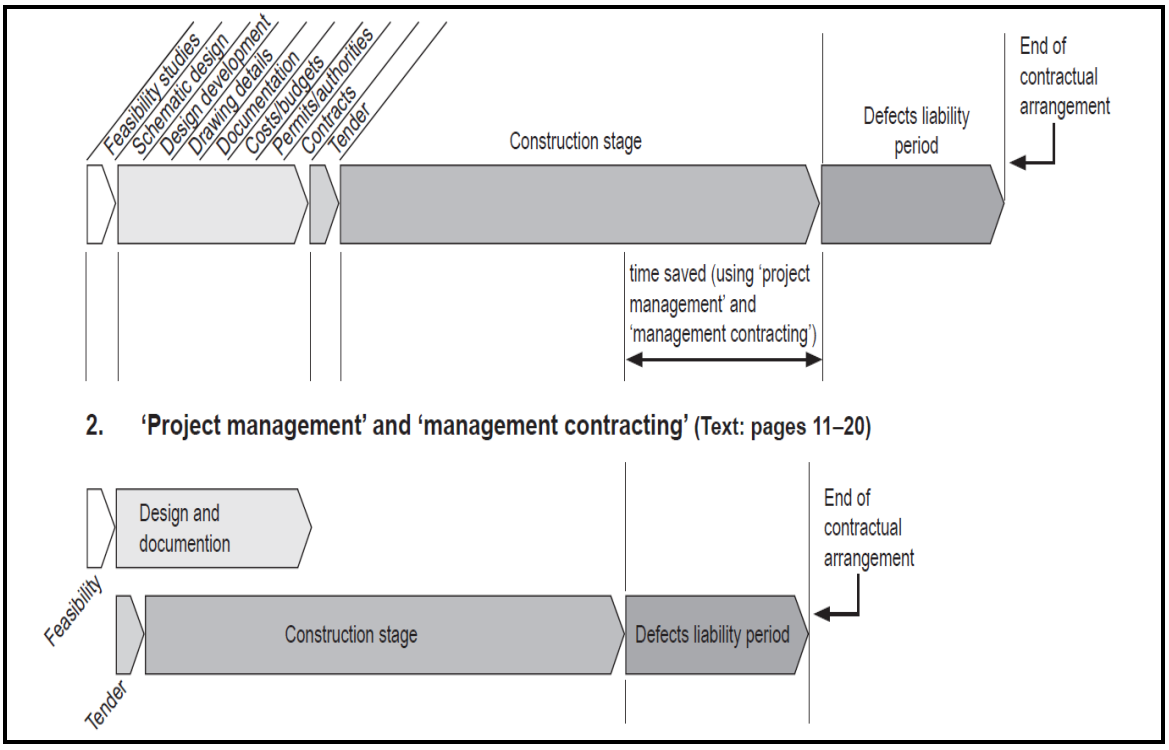

Figure 2: Project Management Planning Process (Malsam, 2018)

There is a variety of factors that lead to poor initial planning and these include the following (Hasan, 2016);

- Inadequate consultation with the client team during the scoping

- Trying to keep the project team in employment and rushing the initial stages
- Continuous changes to the project team/ client during other stages which lead to construction being done while scoping is still being finalized
- 3rd party project reviews by other consultant post value engineering stage which affects the time taken to finish engineering resulting in engineering running parallel with construction.

2.9.2 Inadequate client team consultation

A state of inadequate consultation results from poor upfront engagement and ignoring problems for too long. It can further be attributed to engaging at the wrong levels resulting in a mismatch in scoping decisions. Adequate action plans should be developed so that they guide the project activities to progress as shown in Figure 3 below (Kestel, 2006).

Figure 3: Attack plan. Source: (Kestel, 2006)

Kestel (2006) argues that there is a tendency where executives become involved in the details that should be closed out by the operation/ production team after the project conception stage. This results in engineering delays. The normal flow post

feasibility study approval is as shown in fFigure 4 below before construction can start.

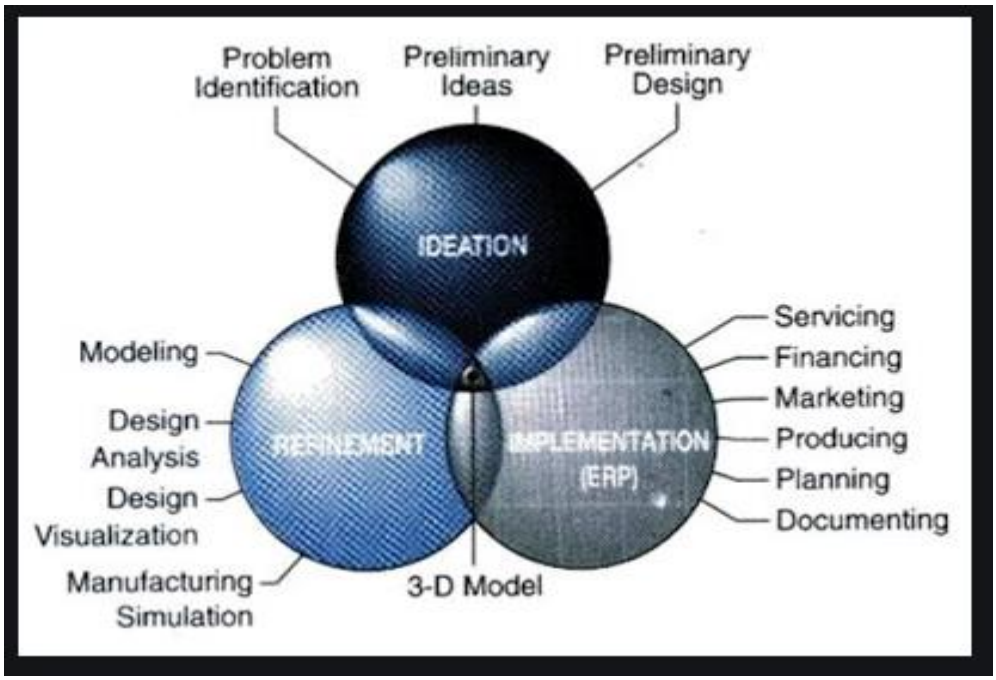

Figure 4: Normal post feasibility study approval process (Kestel, 2006).

Morris (2017) postulates that any changes or revision to the design process flow after the board approval stage affects both the both time and cost as these changes the strategic intent. Any such revision indicates inadequate team consultation.

One aspect worth noting is that the once the board has approved a project, it becomes too difficult to go back and ask more money or to use contingency especially in the early stages of the project. This then forces the project team to continue with what is approved and try and make it work (Morris, 2017).

The basic purpose of consultation is to improve decision-making, and build understanding to enable identification and monitoring of trends, challenges and perceptions over time with specific groups of stakeholders (WBDG, 2016).

2.9.3 Project team dynamics

Teamwork is integral to organisations. Therefore, improving team dynamics can lead to better performance work outcomes and an improved bottom line. Team dynamics are thus the unconscious, psychological factors that influence the direction of a team's behaviour and performance (Ogbonna, 2019).

Managing team dynamics is of importance and the project manager must ensure that there are strategies in place for doing this and enhancing performance in a team.

Team building is the tactical process of group formation and blending of individual personalities, efforts, relationships and abilities towards a common goal. Strategies include but are not limited to conducting interviews with individuals, talking to customers and line managers with a view of gathering information to better existing standards (Deakinco, 2017).

Poor group dynamics management can lead to the following (Deakinco, 2017);

- A dominant team member taking over which leads to conflict and lack of direction
- The team not challenging themselves in decision making and agreeing to everything on the table
- Withdrawal of other team members resulting in inefficiencies
- Team members taking it easy at the expense of others
- Reduced effectiveness
- Deference to authority
- Lack of accountability
- Dysfunctional role

2.9.4 Client team relationship management

Relationship management helps build effective teams where employees respect each other, listen to new ideas and work seamlessly. In Project Management, relationship management is very important for successful project execution. This relationship is set up by ensuring that a clear communication protocol is set up at the beginning of the project, ensuring that promises made to the client are realistic

and achievable, always assisting the client where practicably possible, and maintaining a high level of professionalism (PMtips, 2011).

Relationship Management can be managed by adopting the following:

- Having a clear project vision
- Encourage team work through formal and informal team building activities and meetings
- Ensuring that great work is always appreciated
- Building a culture of listening
- Set cleat expectations
- Develop clear and shared values
- Clear standards and specifications for ease of reference
- Unnecessary changes to the team during project execution

According to Lexology (2015), tight knit teams are high on morale and very productive while poor team dynamics lead to confusion, stress and tension, which negatively affect project execution.

2.9.5 Inadequate resourcing

Resources are used to their maximum potential, keeping projects on time and on budget. Careful resource planning helps project managers keep an eye on the project, reducing oversights and double-bookings. Its purpose is to plan, allocate and schedule the company's resources as efficiently as possible (Xaba, 2011:41-43).

According to Cohen (2020), resource planning is a function of assigning tasks and managing deadlines throughout the lifecycle of the project. However, poor resource allocation is one of the main reasons behind failed projects. Poor allocation can result in wasted money, potential and project overruns. Inadequate resourcing have been attributed to project managers who are incompetent, lacking experience, lack of support structures, internal politics, community involvement, implementation problems, financial contracts, and schedule duration urgency, among others (Xaba, 2011:41-43).

As per Malsam (2018), the project manager's main responsibility is the allocation of resources. These resources can be human, financial, and technical and can be summarized as:

- Translate the Client's needs and requirement into a brief document, generally known as scoping document;
- Establish a team with adequate skills and knowledge to do the project with
- Ensure that systems, procedures, controls are established and adhered to during project execution
- Establish roles and responsibility matrix for all the project members and manage performance
- Interface between the Client and the project team
- Ensure progressive progress review and report accordingly
- Effectively manage changes to the approved scope

Furthermore, resourcing includes engaging the appropriate expertise and contractors who are equipped to see the construction through. A typical construction set-up will have personnel in the technical, administration, legal appointees, safety, quality compliance and assurance (Thompson, P. 1991: 92). In addition, the activities that must be undertaken on site must be correctly resourced as per schedule to maximize their availability thereby controlling costs (Cohen, 2020).

A major resource that requires planning is the unskilled labour. Construction projects opt for local unskilled labour within the area of work influence. Although this is an advantage in that it reduces the need for big construction camps to be erected and serviced, it is disadvantageous particularly, if the community has expectations that cannot be met by the project team.

In addition, there is a period of learning with the unskilled labour and this unfortunately results in inefficiencies during construction (Under Construction, 2018).

Lack of stakeholder engagement as far as unskilled labour is concerned results in strikes and industrial action by local members and this has huge ramifications on the project's schedule and cost. (Projectriskcoach, 2018).

On the other hand, capacity planning seeks to manage the capacity utilization of the identified resources and assets during the duration of project duration. Assessing the loading of resources assists in determining when to recruit additional resources, retire the resource, and re-assign the resource while ensuring the project targets are met (Cohen, 2020).

Of critical importance is the adequacy of existing or new infrastructural resources. These must be checked against the activities and these include the clinic for medical checking, enough functional medical equipment, training facilities, testing facilities, enough training instructors, medical practitioners, etc. (Clarizen, 2019).

2.9.6 Lack of dependency understanding

Project interdependency is defined as a relationship of tasks or projects where one project / activity has a net cascading effect or impact on the next activity. If these are not managed actively, they lead to conflict within the team and can adversely affect project costs (Yesodharan & Mohan, 2021).

This is a manifestation of poor scoping phase and lack of experienced personnel to pick dependencies way ahead of time and react to them. A network diagram using activity on nodes (AON) or the use of a Gantt chart can assist with identifying critical path activities and activities with float to help the project manager make decisions in the best interest of the project. This is further enhanced by a PIM (project interdependency management) which provides tools to manage these (Yesodharan & Mohan, 2021).

Interdependencies are classified as external and internal. These should captured during the planning process. Internal interdependencies include the following (Yesodharan & Mohan, 2021):

- Resource interdependencies: Shared resources and work load
- Technology interdependencies: what systems will be used during
- Technical interdependency: technical knowhow flow between projects
- Knowledge-based interdependency: parallel projects learning from each other
- Scheduling interdependency: this ties in with resource on parallel projects

On the other hand, external interdependency includes:

- Market interdependency: competitive demand

In mining construction, dependencies also include the geology and related structure in underground mining projects relative to how that will affect infrastructure installation. The following are some of the practical aspects that must be taken into consideration (Basson *et al*., 2006:06-11):

- Most of the underground rigging is done using roof bolts assuming that the rock mass or competency is good enough to handle the associated loads.
- The requirement for secondary support (shotcrete) in instances where the rock is very friable delaying handover to follow on trades
- Water fissures and flooding of underground workings during development
- Fall of ground due bad ground conditions
- Ventilation restrictions as new ventilation districts are created during development which may result in suffocating the next operational section or recirculation
- Increased heat loads due extra machines underground
- Means of second egress underground with the introduction of contractors and the adequacy of refuge bays vs number of people underground at a time

If interdependencies are picked up early in the project, these will affect the project design, costing and schedule. Some of the interdependencies will filter into the

risk register as residual risks which need to be managed. Of importance is that they influence the methodology of doing work and the related risks that go along with this (Killen & Kjaer, 2012: 554).

Planning for dependencies during project execution has benefits in that it ensures quality, consistency and timely execution of project deliverables.

2.9.7 Poor change management

Change management refers to a process of managing, controlling and implementing any scope additions and removals in accordance with the approved project procedure. It should form part of the project plan in order to secure a positive outcome if unplanned or planned changes to the project are experienced (Windsor, 2020). This process caters for the following during any phase of the project:

- Technical decision notes: to capture any decision made that can change the original design or concept during the FEED phase or construction.
- Site engineering query or technical engineering query: any clarity required on existing design
- Site instruction: an instruction given to any contractor on site which was not included in the principal scope
- Change note: a document filled in to internally move funds

The above are some of the change management systems that can be put in place and must be captured in procedures to prevent ambiguity during project set up or execution (Basson *et al*., 2006:07-09).

2.10 CURRENT PROJECT STATUS AT MARGARET SHAFT

This process flow shown in fFigure 5 below shows the items that appraise how a project is approved and the input that goes into this from upfront engineering.

The feasibility study include critical steps such as

- setting up the WBS,

- basis of scheduling,
- basis of costing report,
- WBS dictionaries,
- PEMS,
- procedures,
- specifications

This process is shown in figure 5 below.

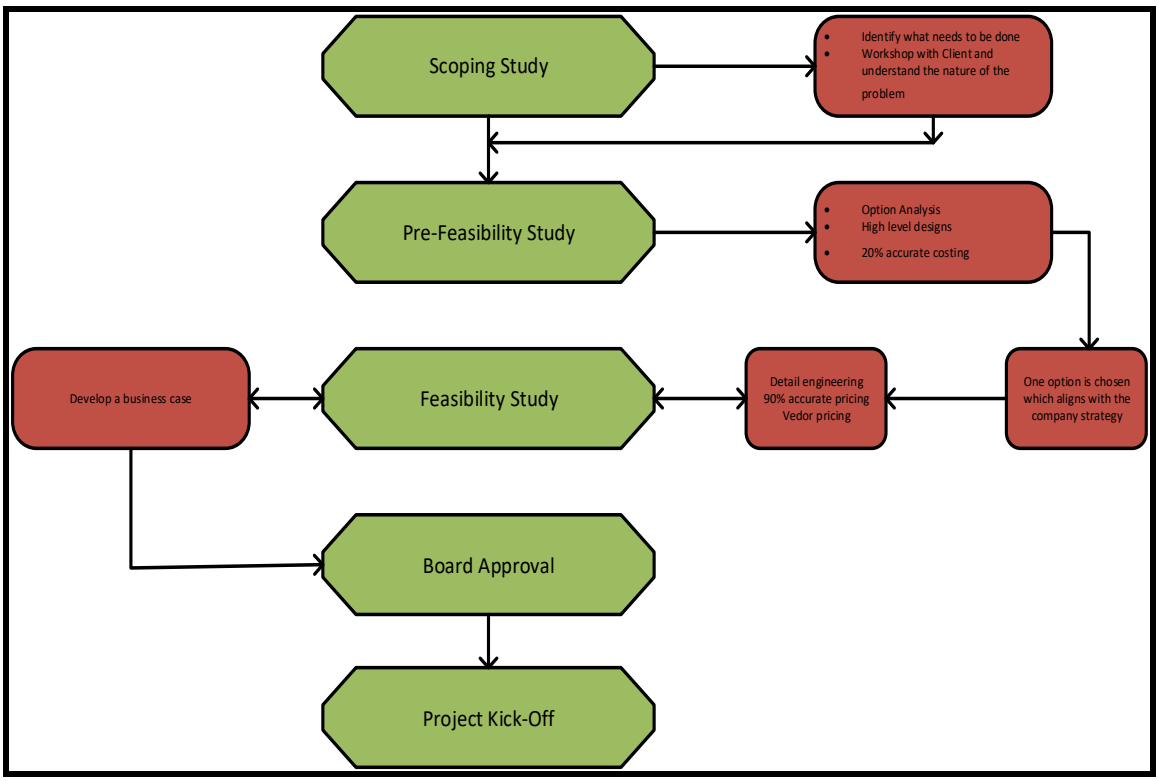

Figure 5: Project approval process flow

Firstly, project kick-off involves setting up and appointing the resources that will be needed. The appointed resources will include the site and these will be to accommodate the need in the PEMS and its associated documents. Then, all procedures will be drafted and approved. The critical project procedures, that are of importance to this study are the construction and commissioning procedure as detailed below.

2.10.1 Construction Process at Company X

The construction process follows the procurement procedure. Before the construction procedure can be drawn, the following should have been completed:

- Drafting of technical scopes and related specifications
- Commercial contract templates agreed and signed off
- Tenders sent and received from the market
- Tenders evaluated, adjudicated and contract placed
- Contract kick-off meetings completed

After the construction process procedure and tenders have been awarded, contractors follow the procedure shown in Figure 6. Its shows a high level of the process that the contractors should undergo post contract award;

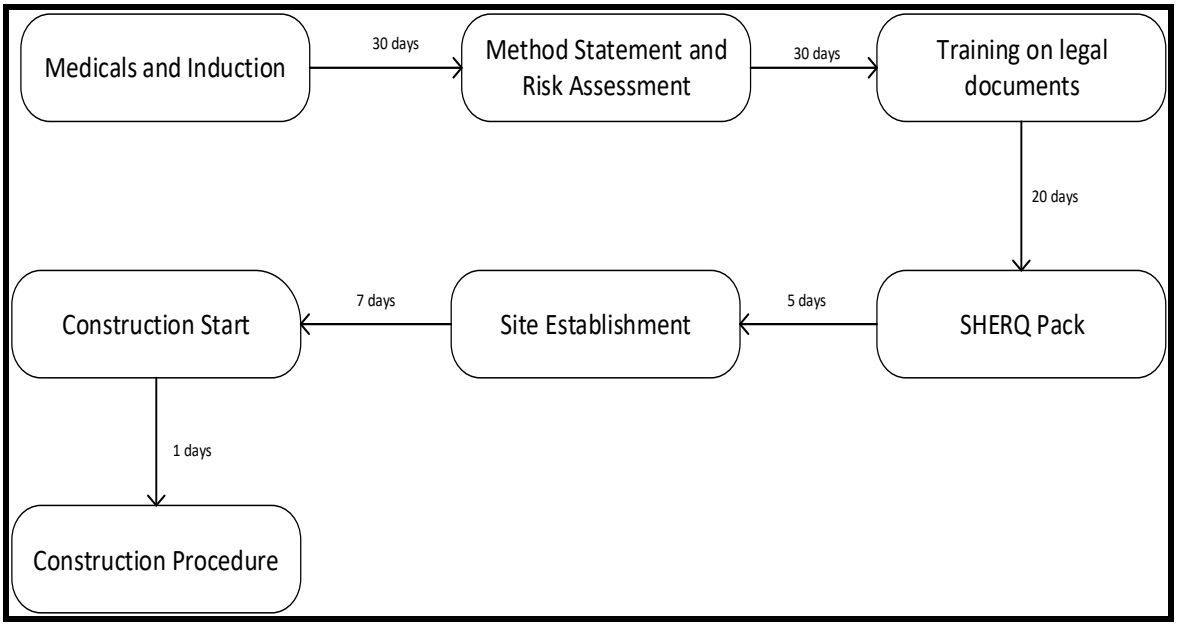

Figure 6: Post contract award process flow

Construction kick off meetings are held to ensure that there is alignment with the site team and that strategic timelines are made transparent to all. The above process normally takes the contractors between 60 to 90 days subject to other factors and constraints on site. The Contractor is not allowed to start with any construction activity until all the legal documents have been signed off.

During execution, the construction and commissioning procedure is mandatory throughout and cannot be circumvented unless approval is attained from the 3.1(a) appointee who in this case is the site project manager. Shown below in Figure 7 below is a high level process to be followed in case there is any deviation from the IFC drawing or a deviation is requested by the contractor on any specification.

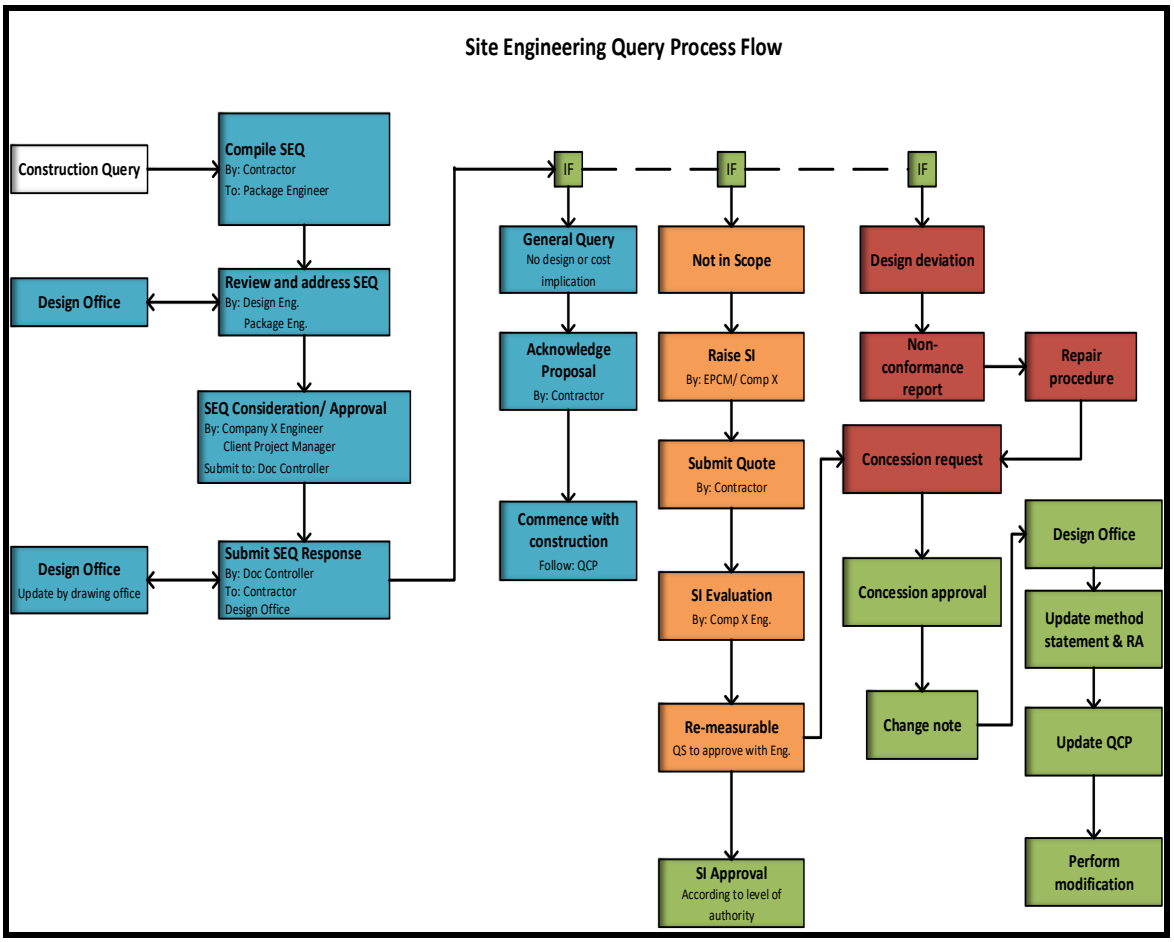

Figure 7: Deviation handling process flow.

When part of the project activity / work is completed, that completed part is subjected to inspection to ascertain its conformity to expectations. This is called the punching procedure with flow details as shown in figure 8 below.

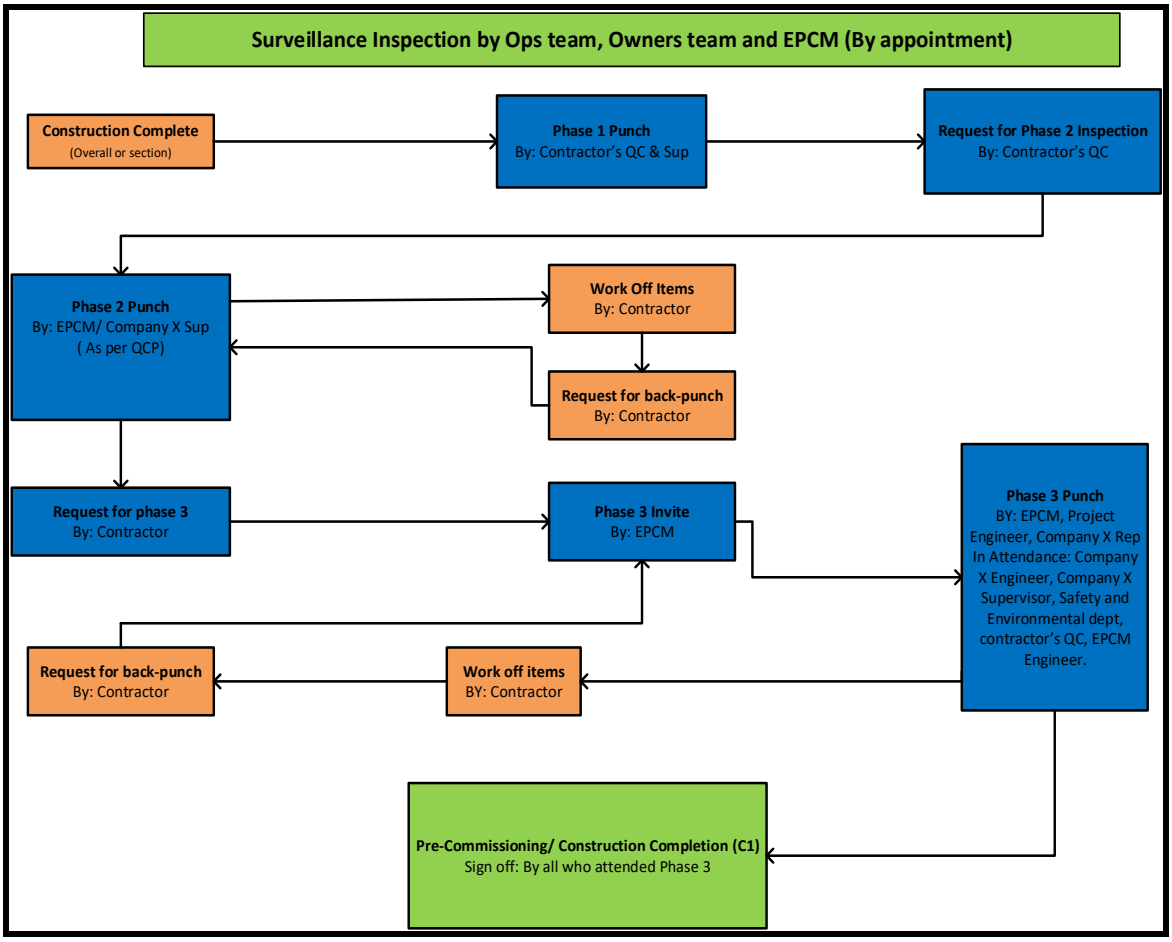

Figure 8: Surveillance Inspection by Ops team

On completion of the above, a C1 certificate is issued which means that the system is ready for commissioning and can be handed over to the team that has been appointed for this purpose. This process is carried out in tandem with the quality assurance team as all the items that are inspected are signed off with the QCP at the same time.

On the basis of scheduling, there is usually a day allowed for punch 1, 2 and 3 with 1 day for C1 sign off. There is no provision made for back punching and working back of all items picked up during the punch.

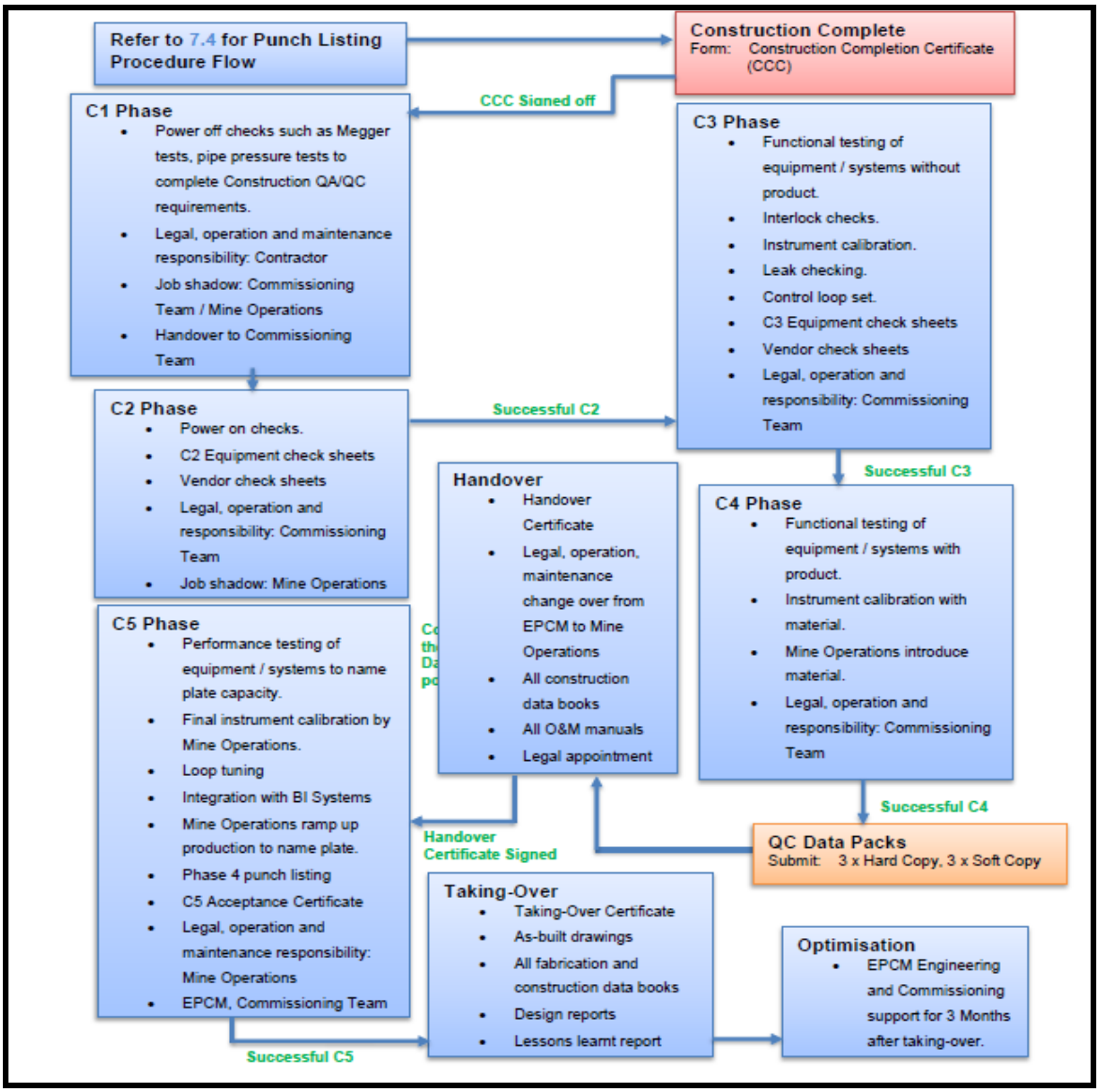

Figure 9: Commissioning Process Flow

This process shows the power on checks until material / ore is introduced into the system and then the system to optimized to operate at name plate capacity. The project team works together with the operations team, the OEM and any third party appointed by the Client to get to handover state. There is normally an umbrella duration allowed for in the baseline schedule subject to the complexity of the system.

2.20 Financial Evaluation

Projects are evaluated by comparing the initial contract placement value to the final cost after completion. The differences, if any, are evaluated by involving the project engineer and the quantity surveyor.

In most cases, the EOT (extension of time) drives the majority of the cost variances and either the employer or the contractor as shown below drives this cost.

Table 2: Financial Impact Evaluation

PROJECT	PACKAGE DESCRIPTION	Contract Value	EOT Claims (Construction late)	Other Claims	Final Account Value	%EOT Claim
Margaret Shaft	EARTHWORKS, CIVILS WORKS AND BUILDING WORKS	R99 027 320,41	R 389 092,78	R166 754,05	R99 583 167,24	0,4%
	EARTHWORKS, CIVILS WORKS AND BUILDING WORKS	R146 779 692,56	R 8 338 283,37	R2 779 427,79	R157 897 403,72	6%
	CIVILS AND SMPP WORKS FOR RAISE SECTION	R203 776 204,62	R 22 776 796,57	R9 761 484,25	R236 314 485,44	11%
	CIVILS AND SMPP WORKS FOR 74 SECTION	R98 634 434,27	R 4 926 667,75	R1 231 666,94	R104 792 768,96	5%
	FABRICATION, SUPPLY AND ERECTION OF SURFACE PLANT STRUCTURAL STEELWORK, PLATEWORK AND PIPING	R166 809 996,81	R 4 122 676,60	R1 030 669,15	R171 963 342,56	2%
	GLORIA UNDRGROUND DEVELOPMENT	R320 131 102,35	R 27 382 904,45	R3 042 544,94	R350 556 551,74	9%
	EC&I imstallation for 74 Section	R58 766 882,94	R 16 669 729,25	R4 167 432,31	R79 604 044,50	28%
Total		R1 093 925 633,96	**R 84 606 150,78**	**R22 179 979,42**	R1 200 711 764,16	8%

In this specific project currently under way at Company X, the EC& I installation, Civils & SMPP and Gloria Underground development were major contributions to the cost variations. These project cost expense items have very high overheads and an increased labour compliment.

In this current project, these three are broad cost drivers and responsible for overruns in the construction project currently being undertaken at Margaret Shaft. However, the specific and underlying causes are not known. This is the subject of this study: to find causes of inconsistent construction methodologies.

2.21 Conclusion

This section revealed the literature behind construction project management. The project, project management, inconsistent methodologies and project life cycle defined and the steps in project life cycle or execution explained herein.

The literature then dwelt on possible reasons why construction projects fail before the current status of a project at Company X Margaret Shaft was detailed. The current project has already experienced some cost overruns and the broad reasons identified from the financials.

The following chapter is to give the research design.

CHAPTER 3

Evaluating the causes and effects of inconsistent construction methodologies on mining projects at Company X, Margaret Shaft

CHAPTER 3: RESEARCH METHOD AND DESIGN

3.1 Introduction

A research methodology includes the rational and philosophical assumptions relative to a particular study. The research strategy details the method to use in conducting the investigation and this forms the framework to follow in collecting and analyzing data (Panas & Pantouvakis, 2010: 63).

This chapter explains the research design and methods used in this research to extract data on the causes and effects of inconsistent methodologies on mining projects at a specific mine in South Africa.

3.2 Description of Overall Research Design

A research design is the overall strategy chosen to integrate different components of the study coherently and logically to ensure that the research problem is effectively addressed (USC, 2020). This research employed a qualitative approach to gather data on the current project at Margaret Shaft. A qualitative research approach also offers more flexibility when collecting the data necessary for the study. Structured interviews were used. These are interviews that strictly adhere to the use of an interview protocol to guide the researcher. It is a more rigid interview style, in that only the questions on the interview protocol were asked.

Furthermore, a cross-sectional approach was used in the research. A cross sectional approach is a type of study design, which focuses on observation and measures the outcomes (Maninder, 2016: 261-264). This approach will assist in evaluating the construction and commissioning methodologies specifically at Margaret Shaft. This includes the time and cost effect on different methodologies.

3.3 Population and sampling

3.3.1 Detail Description of the Unit Under Study

Company X has three mine complexes in South Africa. Margaret Shaft is one of the underground mine complexes owned by Company X in the Northern Cape Province of South Africa. The other two complexes are Shaft A and Shaft B situated 20 kilometres away. The Margaret Complex comprises of two vertical shafts that use drum winder headgears to take both personnel and material underground and a decline shaft to transport personnel. This headgear operated decline shaft is also equipped with a side conveyor belt, running in tandem that takes ore out from underground to the surface plant.

The Margaret Complex or Shaft has an expansion project underway; the other two complexes (Shaft A and Shaft B) have both expansion and stay in business projects underway that will terminate at the same time with the Margaret Complex project. All these projects are mining projects inclusive of infrastructure development underground. Currently, they are five projects running in total.

3.3.2 Technical Description of the Unit Under Study

The selected project for study is at Margaret Complex. In general, mining projects include linear development of tunnels / haulages to get to an ore truck tip with a view of minimizing tramming distances underground. This further includes drop raising of tips / ore passes to store this ore before it is transported to the main belt feeding the surface plant.

In addition, underground infrastructure includes configurations such as conveyor belts, platework, mechanical fabrications, fire and EC&I installations. In general, these projects make it possible to bring man, ancillaries, and material to the rock face, work, harvest the ore, and then be able to move the ore to the surface for further processing. A typical ore flow is shown in Figure 10 below.

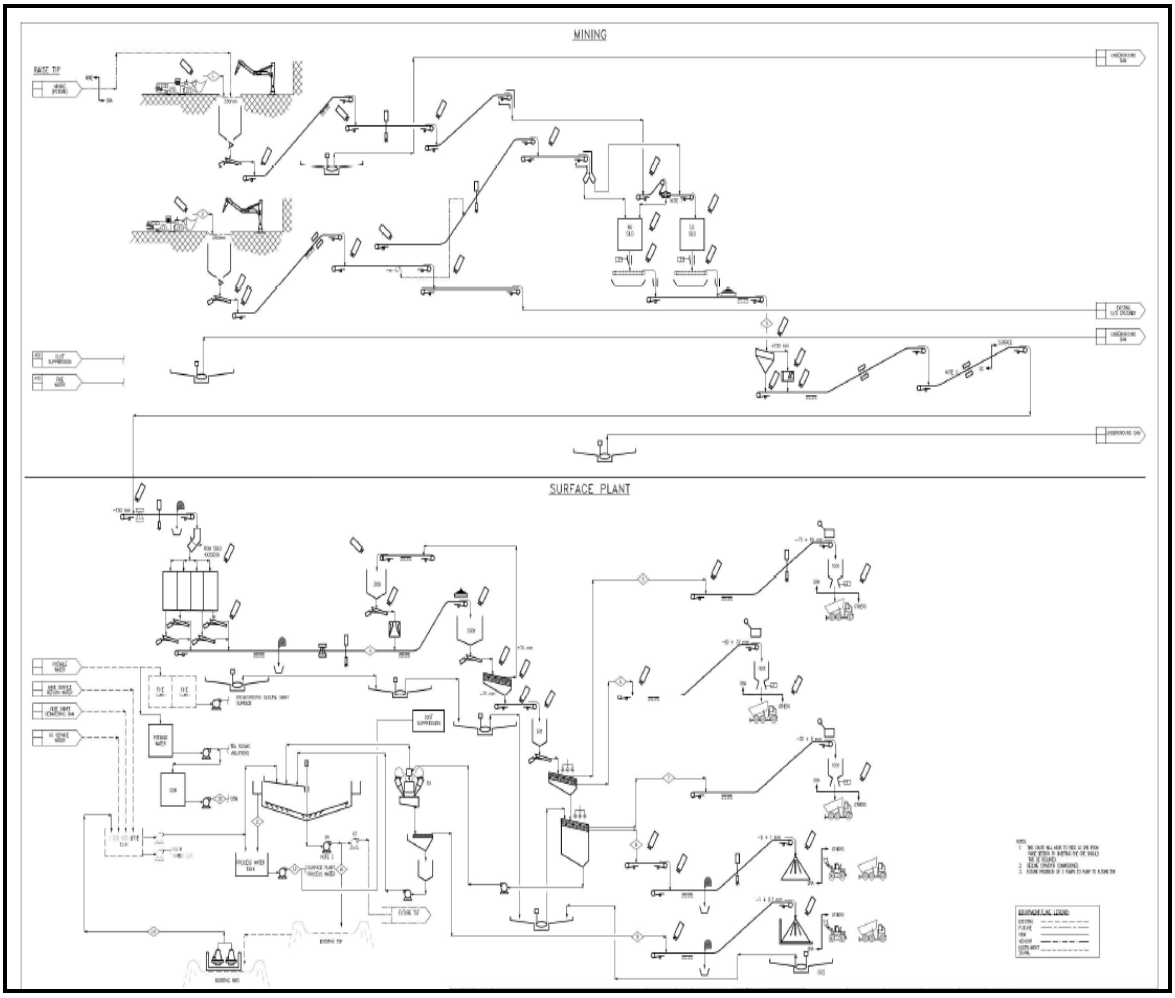

Figure 10: Underground and Surface Ore Flow

The Margaret Shaft Project involves mining in underground sections and installation of infrastructure to feed the new surface plant as shown in figure 2 above. First, all the mining work is completed. This is followed by the installation of all civil works. Then, the structural, platework, mechanical and piping (SMPP) work is completed. After this, the electrical, fire protection and detection work is lastly undertaken before the commissioning team takes over.

On completion of commissioning, the asset is handed over to the operations team for production purposes. The production team forms part of commissioning to make the handover process smooth.

The underground section blends well into the newly build surface plant feeding the 8000 tonne silo which in turn feeds the dry and wet circuit through to the product bins. Product is loaded out by utilizing of trucks to respective stockpiles on

surface. The surface plant is a green field projects (no production, only project work) while the entire underground will be in brownfields area (project happens concurrent with production). Figure 10 above shows the operations circuit.

The study focused on a project from concept stage until hand over to the production team. For the purposes of the study, one major project was selected from the five currently running in Company X.

The selection criteria for the project were;

- Project had to be major one.
- Project was big enough to have an upfront engineering and design work which requires a professional engineer's input during construction
- Projects made use of an EPCM (Engineering, Procurement and Construction Management) Consultant house or at least EP
- Construction work must be executed by Contractors and not done internally

This unit of study will provide data and information needed to answer the problem statement.

3.3.4 Population and Sampling Strategy

In research, the population refers to the focal group from which the researcher will draw conclusions. The population is a totality of persons, events, organization units, and cases with which a specific research problem is concerned and seeks to investigate and find solutions (De Vos, 1998:190; Goddard & Melville, 2001:34).

The population of participants includes the whole workforce for Company X and the external Consulting Project Company. In total, the population is 580.

3.3.5 Study Sample

A sample is selected from a population. The need for a sample is driven by the impracticality of collecting data from the entire population. Budget and time are constraints to surveying the entire population (Saunders and Lewis, 2009). From

the population, participants were purposively selected for the sample. The participants were six top managers in total (five from Company X and one from the Consultant Company). These were the subject experts.

A non-probability approach or purposive project sampling was used in this research and is defined as a non-random selection of a sample based on convenience or other criteria, which allows you to easily collect data with ease (Bryman et al. 2017: 177-178).

The participants selected for the interviews were senior and key project executors who make strategic decisions. All the respondents had good knowledge in the field of study and the data that to be collected will prove invaluable towards answering the research question. In addition, the targeted individuals had over ten years of experience in major projects and as senior managers as well, in their respective areas of employ. The participants were:

- Candidate 1: Lead Project Engineer: Consultant
- Candidate 2: Senior Construction Manager: Consultant
- Candidate 3: Client Clerk of Works: Company X
- Candidate 4: MHSA 2.13.1 Engineer: Company X
- Candidate 5: Project Manager: Contractor MD
- Candidate 6: Project Manager: Company Y

To fulfill the cross sectional nature of the study, an External Consultant Project Manager was selected as well (Candidate 6).

3.3.6 Data Collection: Nature of data to be collected

This research is to extract qualitative data on the causes and effects of inconsistent methodologies on mining projects at a specific mine in South Africa. One project was nominated for data extraction. A sample of six subject experts was purposively selected for interviews. The data collection was in the form of structured interviews where questions were sent to the sample group upfront.

3.3.7 Data Collection Instrument and Process

In order to accomplish the objectives of the study, qualitative data was collected from existing project processes and procedures on the current project at Company X using a qualitative instrument and through scheduled interviews with the targeted participants.

The study made use of structured interviews with a list of constructs and questions designed to extract specific details. The list was sent in advance to the interviewees. This gave the participants and the interviewer freedom to discuss the various topics and questions in depth. The interviewer coordinated the process within the confines of the questions asked. A recording device was used to capture the face to face interviews. The interview questions were meant to elicit perceptions on the four research constructs shown in tables 3 to 7 below which also represent the questions in the interview schedule.

Table 3: Summary of methodology constructs

Construct	**Description**	**Number of questions**
1	SHERQ/ On-boarding process planning and resourcing	5
2	Construction methodologies, method statement and risk assessment process	14
3	3rd party interface process effect on construction	5
4	Change management on site	6

Table 4: Specific items on construct one

SHERQ/ On-boarding process planning and resourcing	
No	Questions
1.	In your opinion, Is enough time allowed for SHERQ build-up & approval and why?
2.	Is the SHERQ process adequately resourced on site?
3.	Do you believe that changes to the SHERQ process on site are continuously updated as construction continues?
4.	In your view, what is the main bottle neck/s that contributes to delayed on-boarding

5.	What do you think needs to be done or improved on to better comply with the MHSA as far as the SHERQ process is concerned?

Table 5: Specific items on construct two

Construction methodologies, method statement and risk assessment process	
No.	Questions
1.	Is the method statement during tender stage consistent with that during execution and is the site involved in the TEAR (method statement review) process?
2.	Does the site team have view of budget constraints prior making decisions on site?
3.	How would you resource the current construction and commissioning procedure that is currently used on site?
4.	Do contractors have the right competencies and skills to do the job they tendered for?
5.	Is the surveying procedure fit for purpose and how would you optimize it?
6.	Is logistics in getting persons and material underground a challenge and how can it be optimized?
7.	How does the employer cover the risk of ground conditions in mining development projects?
8.	How is the production plan aligned with the construction plan/ activities upfront in brown fields projects and how are changes updated?
10.	What are the gaps between daily management (daily diaries) of the contractors on site and overall project schedule and milestones?
11.	Do we need more supervision and planners to better manage the project schedule and why?
12.	Are roles and responsibilities clearly defined between design engineer, project engineer and legally appointed engineer?
13.	What needs to be optimized/ changed in the current quality control system on site?
14.	How can the legal handover between trades be optimized in a manner that does not affect both the schedule and legal compliance?

Table 6: Specific items on construct three

3rd party interface process effect on construction	
No	Questions
1.	Is there adequate alignment with local communities prior to project start?
2.	Do the community forums know what is expected of them and what the project will provide in turn?
3.	What needs to be done to balance local employment and productivity?
4.	What are the contributing factors to delayed on-boarding of local employees?
5.	Do we align the DMR upfront in what the project entails and associated risks?

Table 7: Specific items on construct four

Change management on site	
No.	Questions
1.	Are new procedures given enough time to be implemented and why?
2.	Is time allowed and filtered into the baseline schedule after a change?
3.	Are changes to scope correctly documented, approved, scheduled and costed?
4.	Is change in scope only executed after approval is gained and in what instances do we execute before approval of finances?
5.	Does approval to change in scope happen quick enough to not affect the schedule and costs?
6.	Are movement of resources between the project and the operations correctly handled?

3.3.8 Data Collection Process

The research data were collected through structured interviews, recorded, transcribed, and analysed for similarities and differences. Interviews were set up with the candidates and questions sent to them upfront.

Permission was sought from the interviewees to record the interviews. Interviews where scheduled subject to the availability of the candidates and were shifted to dates that better suited the candidates. All candidates were informed that

participation was voluntary and they were not compelled to answer any question that they were not comfortable with.

Table 8: Interview schedule

Interviewee/Candidate	**Date**	**Time**
Lead Project Engineer: Consultant Candidate 1	4 June 2021	09:00 am
MHSA 2.13.1 Engineer: Company X Candidate 2	3 July 2021	09:00 am
Client Clerk of Works: Company X Candidate 3	28 June 2021	09:00 am
Senior Construction Manager: Consultant Candidate 4	7 June 2021	10:00 am
Project Manager: Contractor MD Candidate 5	8 July 2021	12:00 pm
Project Manager: Company Y Candidate 6	22 August 2021	09:00 am

3.3.9 Recording of Data and Data analysis

The interviews were recorded using a recording application installed on an Apple IPad. This was a secure way of recording the data and the data was automatically backed-up in the cloud storage system. After all the interviews were completed, all the recorded interview data was transcribed. This was done by an institution that specialises in transcriptions to ensure that the integrity of the interviews are kept.

All interviews were recorded and then the answers were evaluated and put into writing. All the answers were appraised for similarities and differences. This formed the basis of the evaluation of the research question.

3.3.10 Suitability of unit of analysis to answer primary research question

Margaret Shaft is best suited for this research because the selected project has only completed 30% of its scope. The other reason is that every company has a set rules for conducting projects and Company X has already established these and used them over years.

The challenge as enshrined in the main research question emanates from within the project division and future costs projections exceeding the allocated budget. Analysing Company X project will identifying key bottlenecks and maybe assist with new ways of doing things congruent with the company culture.

3.4 Assessing and demonstrating the quality and rigour of the proposed research design

3.4.1 Reliability of data

Reliability is defined as the consistency of the participant who is taking a measure with a view that they will constantly give the same answers repeatedly. Reliability has attributes that can be tested for measurement purposes and these are stability, internal consistency and equivalence (Heala & Twycross, 2015:66). It can be enhanced by detailed field notes by using recording devices and by transcribing the digital files.

Interviews were conducted using a set of structured questions on a sample of senior managers who were subject experts. This should assure the consistency of the data received.

3.4.2 Validity of Data

Lincoln and Guba (1985) used “trustworthiness” of a study as the naturalist’s equivalent for internal validation, external validation, reliability, and objectivity. Trustworthiness is achieved by credibility, authenticity, transferability, dependability, and confirmability in qualitative research. (Heala & Twycross, 2015:66).

3.5 Research ethics

The North West University has the following ethical standard as summarized below;

- Reasonable measures must be taken to protect vulnerable participants in any study conducted and this must be declared by the researcher.
- Consent must be attained if information used in the study is deemed confidential or privileged.

- Conflict of interest between the researcher and participants must be declared.
- The outcome of the study must in no way harm the participants nor tarnish their reputation in any way
- Participants must always be informed or briefed about the intention of the study
- Participants must be informed that they can stop participating in the study at anytime

This study will not involve vulnerable participants but consent will be sought from the gatekeepers to interview participants during working hours. Consent will further be sought without divulging confidential information to discuss and publish project related costing for analysis so that recommendations can be made. The study will not make mention of any names but rather designations and there will not be any incentive for all the participants.

3.6 Conclusion

This chapter has outlined the research method and design that was used to gather data in order to answer the study question seeking to evaluate the causes and effects of inconsistent construction methodologies on mining projects.

CHAPTER 4: PRESENTATION OF INTERVIEW RESULTS

4.1 Introduction

This chapter provides the interview results. All the six selected candidates were interviewed representing a 100% response. The recordings were transcribed and presented below as recorded per candidate (table 8 below). The discussion of the results is presented in Chapter 5.

A summary of the sample demographic is shown in table 9 below.

Table 9: Interview demographics

	Interviewee/Candidate	**Age**	**Work Years**
1	Lead Project Engineer: Consultant : Candidate 1	42	10
2	Senior Construction Manager: Consultant: Candidate 2	61	35
3	Client Clerk of Works: Company X : Candidate 3	48	25
4	MHSA 2.13.1 Engineer: Company X : Candidate 4	63	40
5	Project Manager: Contractor MD : Candidate 5	39	15
6	Project Manager: Company Y: Candidate 6	46	20

From table 9, all candidates were males and above 42 years of age. The average age and work experience were 49 years, 24 years respectively while the median age, and years of experience were 47 years and 22.5 years as well. This demonstrates that the sample selected for the qualitative survey was highly experienced. This supports the idea that the data collected was valuable in answering the research question.

The interviews were to elicit perceptions on the following constructs that affect construction methodologies.

Table 10: Constructs in the research study

Construct	Description	Number of questions
1	SHERQ/ On-boarding process planning and resourcing	5
2	Construction methodologies, method statement and risk assessment process	14
3	3rd party interface process effect on construction	5
4	Change management on site	6

4.2 TRANSCRIPTION OF INTERVIEWS

The interview results are presented per candidate and per construct in the following sections in verbatim:

4.2.1 Transcribed Interview Candidate 1: Lead Project Engineer

CONSTRUCT ONE: SHERQ/ On-boarding process planning and resourcing

SHERQ build up and approval allows enough time in the current procedure which is approximately 4-6 weeks. This works for contractors who have previously worked at Company X and know what the requirements are. For a new contractor, this tends to be a challenge as this process takes them 8 weeks approximately which is not in the baseline. Contractor training on this process is a gap that needs to be filled.

The SHERQ resourcing is deemed enough although a recommendation is made to add personnel to assist with training of the Contractors before the actual build-up commences. A RACI is further recommended to help expedite the process and to remove the blame culture when the dates are not met. Evolutionary changes to the SHERQ process and procedures and the related updates cannot be confirmed

although it is affirmed that the contractors quickly adapt to these as and when they are made.

The on-boarding process was delayed because of lack of clear understanding by contractors on what is expected of them and this results in the SHERQ file being reviewed over and over again. Further to this, the potential contractor legal appointees have to be interviewed and this process is onerous in that if one candidate fails this interview the recruitment process has to be re-started even though the contractor deemed that person suitable for the role.

To overall improve this process, it is highlighted that contractor training should be implemented and the amount of paper work can be reviewed with a view of minimizing it and ensuring that the implementation is adequately done and understood.

CONSTRUCT TWO: Construction methodologies, method statement and risk assessment process

The method statement during tender phase and construction are not consistent with each other due to the fact that new role players come onto the project and change the manner in which they prefer things to be done. This is driven by the fact that site teams are more inclined to cater for safety and quality without taking schedule and cost into account. In most instances, preferential engineering takes precedence as the legally appointed Engineer gets to decide what is allowed and what is not. It must be noted that the site team is not involved in upfront TEAR process to inform the methodologies in the planning phase.

Resourcing for the surface projects is adequate enough but when it comes to underground projects there are gaps that needs to be filled. These gaps have not been filled because of budget constraints inherited from the upfront engineering and how the CBE was put together. This gap is further made worse by the fact that the construction team and commissioning team are not working as a cohesive team that supplements one another.

When it comes to the right skills from contractor employees, there is a huge gap not only in the Northern Cape but this is a country wide challenge. Candidates employed have the qualifications but lack practical experience.

The approved survey procedure is fit for purpose looking at the complex structures we are building underground but it can be optimized. The handover process from mining to SMPP for example involves superimposing the design onto the mining profile but this is not done on site but rather at head office by the draughtsman, this takes long at times and delays construction due to software incompatibilities and lack of skills to do that in head office.

From a logistics point of view, a lot of upfront planning happens based on the number of teams envisaged, material required and machine allocation based on practical availabilities. The hurdles identified with this process is the required machines getting delivered late to site and lack of maintenance while the machines are running.

Ground conditions and geological features are not allowed for in the principal scope nor scheduling. These are dealt with on an ongoing basis with the project end date remaining the same. Geological drilling is not done due to financial constraints. The schedule impact is worsened by the project being in brown fields in that production still has to continue. The production plan is aligned with the project plan in the upfront planning phases and when changes happen in production there is no alignment with the project team.

The biggest gap in the daily management system with the project milestone is that the site team manages overall safety compliance and quality management with less emphasis on the schedule. This then means that the daily diary is never aligned with the overall project schedule. The reason behind this maybe that the site team does not have a feel of the project budget nor the related constraints. The challenge is that the site teams are aligned with the roles and responsibilities as far as the MHSA is concerned but functional responsibilities are still blurred. A RACI on functional responsibilities can assist in avoiding duplication and conflict.

Supervision from both the contractor and EPCM is deemed to be adequate to see construction through. The gap identified is the competency of the contractor supervisors who most of the time struggle with technical know-how and experience. Further to this, a gap has been identified from a site planning view in that the project does not have a site planner to help influence the day to day management of the schedule.

The current quality management system is one of the best in the industry and does not need any optimization. This caters for the SEQ's as well which are raised for valid reasons apart from the lack of competency from contractors in raising these. EPCM supervisors have the power to make decisions on items that do not affect the design during construction to minimize the amount of SEQ's and delays associated with that. Legal handover forms part of this system as well and this is handled very well post the document being updated and refined. The overall procedure needs to be updated to cater for the new additions.

CONSTRUCT THREE: 3rd party interface process effect on construction

It is not clear as to whether there is alignment with the community representatives prior to project start as this is always a complex and delicate matter handled at a high level. It must be noted that throughout the execution or construction phase of the project, the need for a community liaison officer has become apparent judging from the complains received from the community.

Engagement has been happening on an adhoc basis with contractors directly talking to the community. A formal system was later put in place and a local recruitment procedure but the effects of this change were not seen as the community was already aggrieved.

The lack of upfront engagement has led to the community having unrealistic expectations as far as salary and other benefits are concerned. This was further aggravated by the request to train and provide proof of training post-employment of all community employees which was not practically possible from a project point of view.

Enough locals are being employed during the construction phase of the project particularly after sign off of the local recruitment procedure. The adverse effects thereof are that locally employed personnel have the qualification but lack practical experience. This affects construction momentum in that the project will be at full complement but the deliverables are not met. To hit the correct balance between local employment and productivity, locals have to be employed as trainees to learn from technical guys with experience so that these can contribute to the sustainability of the mine in the long term.

The recruitment process of local employees and the related procedures have not been filtered into any schedule. This takes long as most of these employees have not been in employment for a long time resulting in them failing medical testing which forces them to come back after 3 weeks for medical re-testing. This then delays the ramp up to full complement on site and has adverse effects on the schedule.

There is further limited consultation with the DMR to make them understand what the project is about and the effect of overall stoppages to the mine in a brown fields environment. This is greatly done in other provinces but not that popular in the Northern Cape Province of South Africa.

CONSTRUCT FOUR: Change management on site

Changes on existing procedures are not given enough time to be implemented and consultation with the relevant stakeholders is not done. These changes are implemented by the site team without consultation with the project engineers and the cost implications are not taken into account as most of the time these changes happen while construction is underway. The schedule impact and related change is not looked into or assessed before any change in procedure is implemented.

New safety related instructions are given on site without taking cognisance of their impact on the overall schedule nor costing. Changes to the principal scope as requested by the Client on site are well documented and an SI will normally be issued to this effect capturing both cost and schedule impact.

Changes in scope are normally not executed before approval is attained unless these are safety critical items. In instances where approval is sort before a change can be implemented, a contractual letter will be sent to the contractor to effect such a change post checking for budgetary constraints. A verbal instruction would then be issued coupled with a zero value SI which will later be captured as a variation.

Movement of labour between the project and operations is well handled although the challenge remains that contracted employees will always look for permanent employment with operations and are always a flight risk.

4.2.2 Transcribed Interview Candidate 2: Senior Construction Manager

CONSTRUCT ONE: SHERQ/ On-boarding process planning and resourcing

There is enough time allowed in the build-up and approval of the SHERQ process. The only challenge is that contractors do not allow for competent persons to drive this process so as to make the timeline. The EPCM resources are adequate enough to enable them to track the progress and to conduct build-up meetings with the contractor. The current process allows for build-up meetings to be held every week, it would be ideal to have this meeting at least 2 times a week so as to intervene early.

Changes to the SHERQ processes are being updated constantly and the contractors are brought up to speed so as not to delay construction. The main bottle necks to this process are as detailed below;

- Plant and machinery pre-inspections before they can be used in the mine takes long
- Local labour recruitment process takes longer and delays labour ramp-up
- The contractor underestimating the intensity of the SHERQ process and starting late with it

The current system as is fully compliant with the MHSA and can only be improved by increasing the regularity of the build-up to SHERQ approval meetings.

CONSTRUCT TWO: Construction methodologies, method statement and risk assessment process

The method statement review during tender stage only involves the project engineer and the client, the site team is not involved and only gets to see the outcome post contract award which is late. Omissions in the principal construction methodology is then adjusted to cater for site specific requirements which adversely affect the schedule and cost. Further to this, the site team does not have a view of the budget but only gets informed by the project engineer what they can do and not do in case of construction variations.

The construction procedure that has been revised is good and creates urgency with the only downfall being that the commissioning team is brought in way too early. One of the other procedure that is more important in construction is the survey procedure, this is deemed to be fit for purpose especially when the results thereof are looked at. The resources brought in for both construction and commissioning are enough to make the process work.

While on resources, the contractors are battling with getting the right skills for the job they tendered for. This is a country wide problem which results in the Site Manager doing both their job and that of the supervisor/ foreman. This has adversely affected the project progress and resulted in resources being changed over and over in the middle of the execution phase.

Logistics is a challenge due to the quality of machines and low reliability achieved to date. This results in reduced face time underground/ construction time which prolongs the project schedule. It is recommended that a new make of machines/ personnel carriers be looked at and that maintenance strategy be beefed up to increase availability. It is further recommended that it would be prudent to have swing units on utility vehicles to allow for maintenance time on existing machines.

The ground condition risk during construction are covered by employing the rock engineers to do constant inspections as development continues. The team then react to what they see and implement changes to make the rock faces safe. The schedule gets continuously updated and cost runs away as there is no upfront

planning done. It is recommended that upfront geological drilling be done to inform the schedule and cost.

Changes to the production plan are not constantly communicated to the project team which is vital in a brown fields project. These changes at times have huge effects that attract millions of Rands on standing and extension of time. It is recommended that the production plan changes be communicated with the project team on a weekly basis so that priorities can be agreed upon on a high level.

Further to this, there are gaps between the daily management tool, which is the daily diary and the overall project schedule. The EPCM planner does not align with the contractor planners to give enough details to be able to effectively implement and manage the daily diary to support the project milestones. The supervisors must be constantly informed by the senior construction manager based on information received from the planner on what to daily focus on. The roles and responsibilities on the project team are clearly defined and there are no overlaps between the head office engineers and legally appointed engineers on site.

The current quality control system is good but can be optimized as handover between disciplines takes longer than planned all the time, contractors are not allowed on the same infrastructure at the same time and QCP's can be simplified and still ensure that they align with the method statement. To try and save on time, the follow-on site manager must visit the area that will be handed over to them way ahead of the formal handover date so that issues can be dealt with progressively.

CONSTRUCT THREE: 3rd party interface process effect on construction

There is a gap that needs to be closed with regards to community liaison and engagement. There is a lot of political interference in the recruitment process and the local Chiefs are no longer in charge although recruitment happens in their villages. The implications of stopping the project and the mine must be explained to the community leaders upfront so that this message can be filtered through to the masses.

The community is well aware of what is expected of them and also know the type of resources that must be recruited for construction work. Political interference is playing a big role in community unrests which in turn affects construction on site. There will always be a challenge in balancing productivity with local employment and from a project's side, time and costs needs to be allowed for to train and transfer skills to the inexperienced local individuals. Senior management must drive this with assistance from the community liaison officer so as to motivate local employees and incentivise them in accordance with the market.

On-boarding of local employees is delayed because the contractor human resources takes too long before they set up and commence with recruitment. Further to this, it would be advisable for the local candidates to be pre-screened for sicknesses such as high blood pressure, weight, eye sight, etc. before they are offered employment. This will reduce failure rate of medicals and inductions drastically and benefit the project as well.

Interface with other third parties like the DMR is done by the operations team and not the project team to align with the existing legal appointment organogram as the 4.1(a) appointee is from the operations team.

CONSTRUCT FOUR: Change management on site

Changes to procedures are implemented immediately and not enough time is given for procedures to be updated. All other procedures were adhered to and change request were approved in time. Operations always take labour from the project and not the other way around.

4.2.3 Transcribed Interview Candidate 3: Client Clerk of Works

CONSTRUCT ONE: SHERQ/ On-boarding process planning and resourcing

The process currently allows for 6 weeks and it is enough time if the contractors come prepared. It is important that the contractors take the lead and not wait for the weekly SHERQ build up meeting before they implement changes. The documents can be reviewed on an adhoc basis so as to help streamline this

process to the benefit of the project. More resources are needed to see this process through compared to what we have now, currently Safety Managers are being charged with this role which detours them from executing their day to day responsibilities.

Continuous changes happen to the SHERQ process and these are updated as and when they happen. Communication of the change does not filter through and there is less consultation before a change is triggered. Further to this, revisions of the SHERQ process are not filtered through to new contractors who have not on-boarded yet and they approach this process leniently and then it takes long for them to get approval which affects their construction start.

The main bottle necks relating to the SHERQ process being late are as follows;

- The contractor employees underestimate this process and do not go through the requirements way ahead of time to be better equipped.
- Contractors tends to have information overload as they start familiarizing themselves with the process very late
- Daily diaries, which are daily site management system to monitor progress does not focus on SHERQ progress but rather on construction only

The current process is adequate enough in ensuring compliance with the MHSA. The process of implementation is not flexible and it is followed religiously even when the effects of such are detrimental to the project.

CONSTRUCT TWO: Construction methodologies, method statement and risk assessment process

The method statement during the tender phase and that when construction starts is not consistent in that the site team changes this document to suit and this affects the schedule. Tender evaluations are done by project engineers who do not carry legal appointments on site and approve the methodology on best practice and this methodology would later be reviewed by the legal appointees after contract placement.

The site team does not have access to the budget nor do they have information about this throughout the life of the project. This then means decisions are made by the site team and instructions given without knowing the impact on the budget.

The resources needed on site to implement the construction and commissioning procedure are adequate enough. The responsibilities at times overlap between the legally appointed engineers and the project engineers including the QA/QC to the detriment of the project. In this instance, procedures are used in a punitive way and not to help with compliance.

On the competency side, there are contractors who have the right competency while others are lacking in this department. What has been seen over the years is that contractors who pay high salaries attract the right type competencies compared to those that do not.

The survey procedure on site is an overkill and it has been adapted to cater for contractor's lack of discipline and lack of competency. The procedure allows for a survey by the contractor on a hold point as per QCP, then produce a report, request for a check survey to be done by the client surveyor before work can continue. This has resulted on too many hold points in the QCP which delays construction.

Logistics is the biggest challenge on site due to lack of vehicles and resources. The little vehicles that are on site are not reliable resulting in high maintenance cost and low availabilities. Since the only way to get to underground workings is through the decline at Margaret shaft, persons and materials are delayed resulting in slow construction progress. These inefficiencies are not allowed for in upfront planning and scheduling resulting in a working schedule which is not achievable.

The schedule is further affected by the effect of mining and the prevailing geological conditions which is not allowed for in the baseline schedule. Geological features are dealt with as development is done resulting in the baseline being fluid.

Brownfield projects are executed while production is underway, this necessitates the production plan to be aligned with the construction plan thus ensuring that the overlaps and bottlenecks are removed in time. This alignment is done but as changes happen to the production plan, the project team is not re-aligned and this attracts standing time, exposure to risk particularly due to TMM's and schedule slippages.

The daily management tool being the daily diary does not align with the baseline schedule nor the working schedule. The team focuses on safety and quality neglecting the schedule and cost part of the project. Delays in the daily diary are recorded and not actively managed as the team does not know which activity forms the critical path.

There are enough supervisors on site to manage construction but there is a gap on the planning side. A fulltime on site planner is needed to assist with aligning the daily diary with the chase schedule.

Roles and responsibilities are clearly defined but on site the legally appointed engineer tends to take over the role of the design engineer and stop construction querying the design and that it will not work or it should be changed. The design engineer and the project engineer responsibilities are well handled and defined and follows the construction and commissioning procedure.

The quality management plan works but the paperwork that goes along with it is onerous. The QCP drives safety and a little bit on quality as it is derived from the construction method statement. This ends up with the quality management system being a paper exercise as quality inspectors do not do daily inspections with the contractor but rather waits for punching at the end and then find a lot of items to be rectified. This method adds a lot of time on construction resulting in project delays.

The handover process has been updated and it is much better now as only the key guys are required to attend this and the responsibility has been given to the supervisors rather than having it central with the 2.13.1 Engineer.

CONSTRUCT THREE: 3rd party interface process effect on construction

The interface with the community was not done upfront. A system was put in place to deal with this post having riots and community unrests which resulted in the appointment of a community liaison officer and the adoption and approval of the local labour recruitment procedure. The community does not know what is expected of them and are not aware of limitations on the project, they come in blind looking for employment.

To balance productivity and local employment, time and cost must be allowed for in the original project planning phase for this. This will then allow skills transfer from the nationals to the locals and expectations can be managed and met between the project and the community.

I am not entirely sure of why the community is not aware of what is expected of them. Further to this, I am not sure if there are external engagements with the DMR on project related matters.

CONSTRUCT FOUR: Change management on site

Safety related procedures are implemented hastily and not enough time is given to get contribution from others. Approvals are attained before work is executed and this process is quick enough to not affect construction. Movement of resources is one sided favouring the mine over the project.

4.2.4 Transcribed Interview Candidate 4: 2.13.1 Engineer

CONSTRUCT ONE: SHERQ/ On-boarding process planning and resourcing

The 6 weeks allowed for the SHERQ process and on-boarding is adequate enough and the contractors do not perform and strive to finish this on time. The process is correctly resourced and does not need to be beefed up.

Changes to the SHERQ process are updated timeously through the safety officer's office and then sent to head office for updating. The main delays on this process are because of poor contractor performance solely. I conclude that the on-boarding/ SHERQ process is perfect and does not need any improvement.

CONSTRUCT TWO: Construction methodologies, method statement and risk assessment process

The site team does not form part of the upfront tender evaluation process including method statement review prior to contract placement. The contractual method statement is changed on site to suit requirements. The site team does not have a feel for the project budget and makes decisions based on MHSA compliance.

The construction and commissioning procedure and survey procedure is properly resourced although the time taken to produce survey reports could be optimized as this takes long.

The contractor competency is good at supervisory level but a level below this lacks knowhow and exposure. I would recommend that technical interviews by the 2.13.1 engineer should be done at this level and not capped at the supervisory level only.

Logistics is a major challenge due to extremely low availability and reliability levels of the existing machines on site. Product specialist from the OEM have been employed to assist with this but senior management must look at different makes to replace the existing. Upfront planning is done correctly aligning the labour histograms with machines.

Ground conditions are deemed the employer's risk and there is no upfront work to help minimize this risk. Mining development work is done and geological challenges dealt with on a continuous basis. The schedule will then be adjusted to align with occurrences on site.

Upfront production plan alignment with the construction plan is done but as changes happen to the production, the construction team is not brought up to speed. Change management in this regard is not followed correctly resulting in construction site stopped to adjust. The daily management tool is perfectly aligned with the overall project milestone.

The supervisors, both the EPCM and contractors are enough to execute the project. This includes for the planners, there is no need for a site planner now and going forward. Roles and responsibilities are clearly defined between all engineers and there are no overlaps.

The quality management system is fit for purpose with no room for optimization, this further includes for the handover process between trades.

CONSTRUCT THREE: 3rd party interface process effect on construction

I am not sure if any upfront community liaison and interaction was done. The local community knows what is expected of them but had more expectations in terms of salary and training.

It is difficult though to get a good balance between local employment and productivity as the community wants immediate gratification although they lack experience. The main contributing factors to delayed onboarding could not be pegged down but maybe attributed to lack of fitness on the candidates. Mitigation to this is recruiting more candidates than needed to counter for the low pass rate.

I am not aware of any interaction with the DMR upfront to align the project scope and its associated risks.

CONSTRUCT FOUR: Change management on site

The change management process is being followed correctly including allowing time to implement new procedures and awaiting approval for any change in scope before it is implemented. The only shortfall is that of resources moving between the project and operations in that operations take resources to the detriment of the project.

4.2.5 Transcribed Interview Candidate 5: Contractor Managing Director

CONSTRUCT ONE: SHERQ/ On-boarding process planning and resourcing

The SHERQ build-up has been allowed enough time for Contractors who are already on site and understand the process. It takes a bit longer for a new contractor who is not site legal yet as they have to coordinate this whole process while not allowed on site. The process is adequately resourced by the Client, EPCM and the contractors to make it within the 6 weeks allowed.

Changes to the SHERQ process are being updated but because of the forever changing requirements, the document updating lags behind resulting in new contractors not scheduling and pricing for the new updates. Further to this, the following are the main bottlenecks in delayed on-boarding;

- The induction, dover test and training of operators (cranes, LDV's and UV operators) is too onerous.
- Further to this, if an operator fails the test, they are given a new timeslot in 2 weeks' time which delays construction commencement
- Medical dates were not available due to the constraints in the clinic but this has become better with time

The process should allow for more work to be done before getting to site particularly the administration. Decentralizing of training, qualification verification and criminal record checks will assist in speeding this process up to the benefit of both the contractor and construction start on site.

CONSTRUCT TWO: Construction methodologies, method statement and risk assessment process

Method statement during tender phase changes when the contractor gets to site and this happens most of the time for newly on-boarded contractors as they do not know site specific requirements which have not been documented yet. Changes on site are made without reference or information on the existing budgets nor any feel for the schedule.

The construction and commissioning procedure is adequately resourced on site looking at the EPCM, contractor and client team. Although the procedure is adequately resourced from an administrative side, the technical competency is lacking behind as the market cannot provide contractors with the required skills-set. Technical personnel are certificated in their respective trades but the technical know-how is lacking. Further to this, employment of local labour is a must to comply with the social labour plan but locals lack experience which affects productivity.

The current surveying procedure is of a very high standard and ensures that infrastructure is erected correctly the first time. It could however be optimized by allowing the contractor and client surveyor to do survey at the same time as opposed to the current system where the contractor must first survey, produce a report and then request the client to check survey before construction can continue.

Logistics on the other hand is a challenge particularly in a brown fields projects as underground equipment that takes resources down is shared between the project and operations team. This could be alleviated by ensuring that the project has its own equipment, workshops and resources to look after these machines for the duration of the project.

In order to avoid standing and extension of time claims because of poor geology which could not have been planned for, it was recommended that the project be scheduled incorporating hospital jobs or fall back jobs to ensure that in cases

where the follow on teams are meant to stand, they can be re-allocated to these jobs.

Production plans are nicely aligned with construction plans upfront and updated as construction continues although there are lags at times. This goes hand in glove with the daily management tool which dovetails with the overall project milestones although adherence to the schedule is a challenge for underground projects.

More supervision is needed on site to help manage the schedule. This will relieve the construction managers from meetings and more time can be spent underground with the teams and optimizing construction sequences and adherence to safety. Roles and responsibilities between all is clearly defined with no overlaps.

The quality management system is of good quality but can be optimized by doing inspections parallel. This means that while the contractor is busy with construction, the EPCM and client quality inspectors must do inspections and point out what needs to be fixed rather than waiting to be called out. The candidate added that the request for inspection should be removed in totality from the procedure.

Legal handovers between trades have drastically improved or has been streamlined over time. Due to limited legal appointees, contractors should put in the request for handover well in advance to prevent legal appointees not being available. Of great importance, handovers need to be scheduled in the overall planning.

CONSTRUCT THREE: 3rd party interface process effect on construction

Alignment with communities is done by the operations team and contractors are not part of that alignment. This process is not easy at all as expectations cannot be managed with the forever changing demands. The community is well aware of what is expected from them and what the project will provide but they are not

satisfied with that. Community leaders do not embark on this process for the community but rather for self-enrichment.

To balance local employment and productivity, there has to be a distinction on the outcomes based on how long the contract will run. In instances of long term contracts, training and associated costs must be allowed for to ensure that there is skills transfer between national experienced guys and the locals. For short term contracts, locals should not be considered at all as the work has to be done quick and contractual penalties do not allow time lost due inefficiencies. A comprehensive list of locals showing those with experience and the novice should be drafted and updated to make it easier to recruit and employ.

The main contributor to delayed on-boarding is medical testing failure by locals. This can be attributed to social factors as most of the communities stay far away from town resulting in most of them being heavy alcohol drinkers, subjects of substance abuse, etc. It must further be noted that due to high unemployment rate, the locals are not physically active as well.

Apart from locals, all other affected and interested parties are aligned and interfaced with before the project starts including the DMR.

CONSTRUCT FOUR: Change management on site

New procedures are given enough time to be implemented but, changes are not filtered through into the baseline schedule as most of these changes are safety related and have to be implemented immediately.

4.2.6 Transcribed Interview Candidate 6: Project Manager Company Y

CONSTRUCT ONE: SHERQ/ On-boarding process planning and resourcing

Allowing up to 2 months for the SHERQ process is deemed adequate enough. Contractors underestimate the complexity of this process and they do not read and understand the requirements properly before time. The electronic way of testing TMM drivers prior to SHERQ approval is a challenge in that most of the operators cannot comprehend this as they are not computer literate.

Lack of adequate resources from the client's side is a shortfall as they are only resourced to align with the maximum persons that can be accommodated per day without any room for an upset condition. This then only allows a certain number of persons to do medicals and induction per day and no extra personnel are allowed even if there was a need to accelerate the schedule.

Updates to the SHERQ procedures are not done in time resulting in new contractors not pricing the tender correctly and establishing inadequate personnel to the detriment of the construction schedule. This is the case with most of the safety critical items like appointing of an offloading crew headed by a rigger with a read seal while the contractor would have allowed for the construction crews to offload trucks on site.

The electronic TMM test can be reviewed especially for old drives. The security clearance procedure must be re-looked at with a view of making it quicker.

CONSTRUCT TWO: Construction methodologies, method statement and risk assessment process

The inconsistency in method statements between upfront tendering and construction is a huge problem in that the individuals who are in charge of approving method statement during tender stage are not the same as those on site resulting in different methods being adopted which may have a cost and time impact on the project.

Decisions made by the site team are in the best interest of safety only as they do not have sight of the overall project budget and constraints.

The construction and commissioning resources at Company Y are in principle the same as those in Company X. The only difference is that the supervisors are charged with ensuring that quality systems are adhered to while the client quality department only focuses on 3rd party audits and they do not influence day to day construction methodologies.

The western limb of the North West province is fortunate to have the right skills from contractors but they battle with discipline in that local employees do not come to work daily and on time.

The survey procedure is the same as that of Company X with the only difference being that the contractor survey, EPCM survey and client survey all happen at the same time and there is no request for check survey. This makes our process quicker compared to that of Company X which involves the contractor requesting for a check survey post printing their survey report.

Logistics to underground working is a challenge due to tight shaft schedules coupled with production being underway at the same time. Further to this, the design interface must be done to ensure that mechanical equipment is so designed to accommodate turning radii underground to avoid construction delays. Construction in underground workings is reduced by 40% due to travelling times and equipment availability.

I do not have enough experience to talk to mining risks in development but I can confirm that upfront drilling is done and continuous condition monitoring is undertaken as well. Further to this, production plans and construction plans were nicely aligned at the beginning of the project but adherence to those plans was a challenge especially from the operation's side.

Daily diaries are aligned with the overall project schedules including milestone dates. The gap that was identified was that reporting from the contractor's side happens a day later and things are not responded to immediately and this leads to

shifts lost which affects construction badly. A different setup must be looked at on how daily diaries can be optimized.

There is no need for extra supervision nor extra planners on site at Company Y. Construction managers must drive the schedule and be diligent in achieving project milestones with the current team configuration.

The interface between the design, project and legally appointed was never an issue at any of the sites that I was in charge of and the RAM was clear to all. Handover between trades happened in accordance with the construction and commissioning procedure but it can be optimized to allow for beneficial access even when C1 certificate has not been achieved from the previous trade.

CONSTRUCT THREE: 3rd party interface process effect on construction

All client interfaces with the local communities happens upfront and there is a process in place for this to happen which all communities are aware of. The only gap identified was that the communities have high expectations over and above what the mine or the project can offer.

Training and exposure of local communities must be done to equip them for future projects although this might be a challenge when it comes to remuneration while they are undergoing training. Introduction of new systems for competency test is the biggest bottle to quick on-boarding.

CONSTRUCT FOUR: Change management on site

New procedures are not given enough time to be implemented. Time is only given if it was a big change which will affect cost in a big way, then the full change management process is implemented. This arrangement leads to these small delays becoming huge when added all together.

All change in scope items are only executed after approval is attained but small items are executed immediately especially if they are safety related. All these changes are done without the schedule being adjusted for them and this puts

strain on construction which ends up reporting unrealistically to keep the client happy.

Movement of labour between operations and the project is catered for in the contractual document talking to the fact that it is not allowed. In practice, construction personnel move from the project to work for operations due to better job prospects to the detriment of the project.

4.3 Conclusions

The interviews were conducted ethically and the information captured on a recording device. The recordings were then transcribed.

CHAPTER 5

Evaluating the causes and effects of inconsistent construction methodologies on mining projects at Company X, Margaret Shaft

CHAPTER 5: DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The research was to evaluate the causes and effects of inconsistent construction methodologies on a mining project at Company X, Margaret Shaft.

Chapter One outlined the research objectives, background and problem statement while Chapter Two gave the underlying literature. Chapter Three gave the research approach and Chapter Four provided the interview results. This chapter discusses the results, gives the conclusions and the recommendations.

5.2 DISCUSSIONS

The results from all the six candidates (as shown in table 9) are discussed per each construct and presented below.

5.2.1 Construct One: SHERQ / On-boarding Process Planning and Resourcing

Construct One was identified in the literature as one of the causes of inconsistent construction methodologies if not managed properly.

From the qualitative results, all the six candidates generally concurred that SHERQ and on-boarding process factors were fairly scheduled, resourced and well managed by contractors and the project team at Margaret Shaft on this specific project and other projects as well.

Candidates one to five agreed fully that the four to six weeks allowed for the SHERQ, the contractor on-boarding process, and the process of allocating of resources was acceptable enough as not to delay the project. In essence, the results indicated to a large extent that this construct does not result in inconsistent

methodologies. Despite this general consensus, the candidates identified areas of improvements / optimisation and these are:

- Candidates one and six indicated that new contractors generally needed up to 8 weeks of onboarding. They identified contractor training as a gap in the process needing attention. In some instances, contractor-appointed legal representatives fail specific Company X interviews and the onboarding process has to be re-started again.

- Candidate two also indicated that sometimes contractors employ incompetent persons and this slows down the process.

- Candidates two, three and six further confirmed that contractors underestimate the complexity of the on-boarding process and they do not read and understand the requirements properly before time. This slows down the process.

- Candidate five suggested that decentralization of activities to allow contractors to do medicals with other medical practitioners will help to reduce the strain on the current system.

- It was suggested to reduce the intensity of testing (Dover) for crane drivers, UV operators and LDV drivers as most of the candidates who have been drivers for years fail this because of lack of computer based testing.

- It was also highlighted that additional time for on-boarding should be allowed for completely new contractors as the current 6 weeks is not enough for them to learn the system and perform.

The major factors identified that cause delays to on-boarding where attributed to the following:

- New contractors not knowing the system
- High level of unfitness particularly on local employees resulting in medical test failures
- Complex driver testing for machines that they have been using for decades
- Contractor mobilizing employees late to site due to delayed job offers, etc.

5.2.2 Construct Two: Construction Methodologies, Method Statement and Risk Assessment Process

Construct Two, which consists of construction methodologies, method statement and risk assessment process was identified in the literature as one of the causes of inconsistent construction methodologies if not managed properly. Candidates had diverged responses on this construct. The following is discussed:

- Five of the candidates (except 5) where of the opinion that the adopted method statement during the tender phase got changed post site establishment to align with what the site team deemed important to them and to better comply with the MHSA. This had an effect of changing the direction and schedule of the projects and will cause inconsistencies.
- Secondly, all candidates except the contractor project manager (candidate 5) confirmed that the site team was not part of the TEAR (Tender Evaluation and Adjudication Report) process. This is indicative of inadequate client team consultation and adds to confusion during construction. It affects team dynamics in the end.

- The sample confirmed that the site team does not have access to the budget nor the knowledge of the budget contents. This points to a communication problem as highlighted in the literature. Furthermore, changes to the production plans are not communicated constantly to the

project team. These changes have cascading effects that negate the bottom line due to extension of time requests.

- All candidates confirmed that the current construction and commissioning procedures are adequately resourced. However, this could be better optimised by allowing an extra site project manager to allow the legally appointed construction manager (MHSA, Reg. 2.6.1) to spend more time in the field.

- All candidates confirmed that there is huge skills shortage (human resources) in the country particularly of technical personnel. The situation is critical. It will deteriorate further if no interventions are implemented. There is personnel with the qualifications but lack practical expertise. It was further alluded that skill shortage is worsened by the need to employ local personnel in order to comply with the approved social labour plan and provisions of the EIA.

- The survey procedure is fit for purpose in general with the exception of one candidate who was of the opinion that the request for survey must be done away with and both contractor survey and check survey to be done simultaneously to save time.

- The results indicated that logistics, especially, in a brown fields projects remain a key bottleneck and this is coupled with poor equipment availability and reliability. It was confirmed that effective construction time is reduced from 7.5hrs per shift to between 4.5-5.5hrs, which is 27% less than planned affecting the completion time and associated costing. Vehicles are a basic problems affecting logistics.

- Ground conditions in mining are critical. It was highlighted that no mechanisms have been put in place to cover the employer's risk for ground conditions as this is handled post contract award and somehow catered for with contingency fund.

- Upfront production and project plans are adequate and 100% aligned. However, not all events are planned for. As the project progresses, changes inevitably occur due to market demands, logistics, geological conditions. These changes affect construction as in some instances production machines would be moved to mine closer to where construction is. This results in delays as legal documents such as traffic management plans, risk assessments, etc. have to be re-done and crews have to be pulled out or stopped while this happens. To manage this, upfront planning has got to be meticulous.

- Furthermore, from a planning perspective, there is no need for more planners over and above the site planner and the overall project planner. However, four candidates confirmed the need for extra resources to handle administration thereby relieving technical personnel to do construction work.

- Five candidates confirmed that there are no major gaps between the daily management system and the overall project schedule. Candidates confirmed that these are aligned although there are times that changes take long to be implemented into the overall schedule which in turn makes daily management a challenge.

- Roles and responsibilities are clearly defined between all fraternities of engineering with a minor gap identified with the legally appointed engineer making decisions that should be made by the design engineer.

- The current quality control system is adequate as highlighted by the results. However, it lacks inclusiveness in that the EPCM supervisors and the contractor supervisor did not complement each. The proposal from four candidates was to conduct parallel quality inspections and do corrective work while construction was underway as opposed to waiting to be called for an inspection.

5.2.3 Construct Three: 3rd Party Interface Process effect on Construction

Construct Three, which consists 3rd Party Interface Process effect on Construction was identified in the literature as one of the causes of inconsistent construction methodologies if not managed properly. The third party interface system's effect on construction yielded the following results;

- All candidates agreed that there is adequate alignment between Company X operations team with the local communities as far as 3rd party interfacing is concerned. However, there is no alignment in terms of deliverables and expectations.

- Five candidates were of the opinion that outcomes of the alignment sessions did not filter from the project team to the community until it was too late and this puts the communities in grievance. This is a source of inconsistent construction methodologies.

- Furthermore, four candidates felt that the communities knew what was expected of them but demanded more. This was understood to be fueled by political influence and the local chiefs who head these communities got sidelined for more militant and self-appointed leaders. This makes the interface process complex.

- Three candidates recommended that the employment of locals should be confined to small projects, which are not critical. This agrees well with the communities' lack of skills and the need to finish work in time coupled with the penalties implications on the contractor on production delays on the mine side.

- It was believed that the DMR was aligned upfront by the operations team as this has not hampered construction work to date.

5.2.4 Construct Four: Change Management On-Site

Construct Four, which consists Change Management On-Site was identified in the literature as one of the causes of inconsistent construction methodologies if not managed properly. Change management related to both on site and off site and its effect on construction is discussed below:

- Candidates one, two, three and six agreed that new procedures are not given enough time to be implemented in the schedule. Time is only given when the changes have significant material effect on the project. Only then, is the full change management process implemented. These candidates concurred that the sum effect of these small delays becomes huge.

- On the contrary, candidates four and five mentioned that the new procedures are given enough time to be implemented. However, the changes are not filtered through into the baseline schedule as most of these changes are safety related and have to be implemented immediately. The only shortfall was that these changes are never scheduled nor is the contractor compensated for such a change.

- All candidates confirmed that changes to the scope were done correctly, documented and approved accordingly.

- Changes to the scope are only implemented after approval is attained unless the activities are safety critical. In such a case, the changes are implemented immediately.

- All candidates confirmed that approval for any change happens quick enough and if the cost is known at that time and it is a safety critical items, a zero value site instruction (SI) will be given and cost sorted out in the background.

5.3 CONCLUSIONS FROM THE DISCUSSION

The discussion of the results from the six candidate show that, in general, the project is well managed from a construction point of view and that most of the systems are in place and align with the PMBok eleven knowledge area in project management.

Legal appointment structures comply with the provisions of the MHSA read with the Mineral Regulations and the SHERQ process ensures that competent candidates are recruited and employed.

There are however areas that can be optimized to assist with helping the project/ construction team better achieve the milestone dates. From the discussion, the following can be summarized as items that needs attention as they result in inconsistent construction methodologies.

5.3.1 Factors from Construct One that causes inconsistencies

The factors identified to cause inconsistent construction methodologies are summarised in Table 11 below.

Table 11: Summary of Inconsistencies – Construct One

Construct One: SHERQ Process & On-boarding			
No.	**Factor**	**Cause**	**Delay/Effect/Impact**
1.	Prolonged on-boarding time	▪ Contractors who have worked at Company X treated the same way as new companies and allowed 6 weeks for SHERQ build-up ▪ Build-up feedback sessions held weekly and not daily	▪ Project completion ▪ Production start ▪ Cost to the contractor
2.	Operator training requirements	▪ UV, Crane driver operator testing intensity without recognizing RPL ▪ Introduction of simulators which old drivers cannot work with	▪ Project completion ▪ Production start ▪ Cost to the contractor
3.	Medical	▪ High failure rate of medical tests	▪ Project completion

	testing failures	(RFA) ▪ Congestion in the mine's clinic ▪ Delays in doing security clearance which is only done at the mine	▪ Production start ▪ Cost to the contractor

5.3.2 Factors in Construct Two causes inconsistencies

The factors identified to cause inconsistent construction methodologies are summarised in Table 12 below

Table 12: Summary of Inconsistencies - Construct Two

Construction methodologies, method statement & RA			
No.	**Challenges**	**Cause**	**Delay/Effect/Impact**
1.	Changes in method statement post contract award	▪ Site team not part of the TEAR process ▪ Method statement changes not scheduled ▪ Lack of project budget knowledge before decision are made	EOT cost to the employer Project completion delayed
2.	Lack of skills and right competencies from contractor employees	▪ National challenge ▪ Recruitment of local labour with no skills	EOT cost for the contractor's account
3.	Constrained logistics to underground workings	▪ Work schedule on 7 hrs vs 5hrs actual ▪ Equipment reliability and availability	Time and cost effect on both the employer and the contractor
4.	Adverse mining ground conditions	▪ Lack of upfront geo-tech work	Time and cost for the employer's account
5.	Inadequate site supervision	▪ 2.6.1 spending 80% of their time in administration duties and meeting	Time impact on both the contractor and employer

5.3.3 Factors in Construct Three causes inconsistencies

The factors identified to cause inconsistent construction methodologies are summarised in table 13 below.

Table 13: Summary of Inconsistencies - Construct Three

3rd Party interface process on construction			
No.	**Challenges**	**Cause**	**Delay/Effect/Impact**
1.	Delays due to Local labour recruitment	▪ High salary expectations ▪ Less productivity due to minimal experience ▪ High rate of medical testing failures ▪ Mine stoppages due to unrest	Cost impact to the contractor and project delays

5.4 CONCLUSIONS

It can be concluded that projects at Company X, Margaret Shaft are executed to high standards, which align with the industry norm. The crosses sectional study through candidate six also revealed high standards of alignment.

The study revealed sources of inconsistencies and the challenges affecting construction methodologies. The conclusions are given in tables 11, 12 and 13.

Recommendations are given below.

5.5 RECOMMENDATIONS

The following recommendations for Company X are drawn from the discussions and shown in tables below;

Table 14: Construct One: SHERQ Process & On-boarding

CONSTRUCT ONE: SHERQ Process & On-boarding	
Challenge	**Recommendation**
Prolonged on-boarding time	Allow a blanket 8 weeks for on-boarding process and revise the existing site procedure to include for contractors to give feedback of the SHERQ process in the daily diary
Operator	Training that is valid from other mining houses should be accepted as

training requirements	proof of competency for operators as all mines uses the MHSA. The mine must further allow for manual assessments of old drivers from the old MTA and not force them to use simulators which they are not used to. This must be written into the procedure and use age as the distinguishing factor.
Medical testing failures	Allow Contractors to do medicals at an approved medical facility and bring proof to site for record keeping by the mine. SHERQ procedure to be updated to include this.

Table 15: Construct Two: Construction methodologies, method statement & RA

CONSTRUCT TWO: Construction methodologies, method statement & RA	
Challenge	Recommendation
Changes in method statement post contract award	Allow the legally appointed engineer a chance to review contractor's method statement during the adjudication and before contract award. This will ensure alignment and the schedule will not be affected.
Lack of skills and right competencies from contractor employees	A procedure must be drafted and agreed to with the mine on which projects will attract local employment so that enough time is allowed for to do training and skills transfer without jeopardizing both the contractor and the mine. This will help with uplifting the community and to put them in a better position to positively contribute in future and to reduce the pool of unskilled labour in the community.
Constrained logistics to underground workings	The project team should plan to have their own equipment upfront during project planning and budget for these. This should include maintenance personnel enough to service these machines and adequate provision must be made for replacement spares. Project baseline planning, construction time per shift must be area based subject to travel time to those areas. A blanket 7.5hrs must not be used for all areas as the mine has working places that are more than 7km away from the shaft and travel time is 2 hours' round trip.
Adverse ground	In all underground projects, cover drilling should form part of the

conditions which affects mining advance rates	upfront engineering and study work undertaken by the team. The geology report should inform the scheduling and costing taking into account all faulting, intrusions, etc. in the development rates. This will help manage stakeholder expectations. Further to this, especially in brown fields projects, geological information can be attained from the MRM division which can be used as a base and input into the mining design criteria.
Inadequate site supervision	The project team must look into divorcing the legal organogram from the functional organogram and resource them accordingly. This will highlight the need for a site project manager who will handle day to day reporting and ensuring compliance with all project procedures. The legally appointed 2.6.1 construction manager will ensure adherence to the MHSA and monitor progress underground without sacrificing on safety.

Table 16: Construct Three: 3rd Party interface process on construction

CONSTRUCT THREE: 3rd Party interface process on construction	
Challenge	Recommendation
Local labour recruitment	In the original project budget, provision must be made for salaries and benefits of the local and national labour to be the same. Enough time must be allowed for locals to undergo long medicals, training and skills transfer. Upfront meeting must be held jointly between the mine and the project to align and curb expectations from the local communities. Local recruitment procedure must be adopted by all appointed chiefs including the municipal mayor within the agreed radius. The project must have a community liaison officer who will work hand in glove with the operations teams.

5.6 MEETING RESEARCH EXPECTATIONS

5.6.1 Meeting the core research question

What are the root causes of inconsistent construction methodologies on-site and their related effects on a project?

The six candidates managed to offer the root causes of inconsistent construction methodologies. These were summarized in tables 11, 12 and 13 under each construct.

The effects are prolonged onboarding time driven by high rate of medical testing failures, complex training for operators and lack on decentralizing this function from mining operations. Local labour recruitment which falls under a separate construct also contributes to pro-longed onboarding as this process takes long based on the approved recruitment procedure.

Further to this, misalignment in construction methodologies during contract placement and execution has a huge impact on the time it takes to build infrastructure. Logistics to get both persons and material underground compounds this as associated delays/ challenges are not included in the basis of scheduling done upfront.

Finally, skills shortage also contributes to this in that personnel with the required qualifications do not have the relevant practical experience and know how. This is further aggravated by administration requirements that are pursuant to MHSA compliance resulting in the supervisors spending more time doing administrative duties rather than actual supervision underground.

5.6.2 Meeting the Specific Research Questions

From the core research questions, the specific questions are as follows:

1. **Is the construction method statement and risk assessment process consistent from contract approval to completion of construction activities?**

   The results from study indicates misalignment between of methodologies between these two crucial stages of construction management. This misalignment has a huge bearing on time and in turn costs because it varies vastly with the original action plan.

2. **Is the 3rd party interface process correctly handled not to affect construction?**

   The study produced positive results indicating that this process was correctly handled but mostly affected by political interference and personal gain.

3. **Is change management on site handled in a manner that does not affect cost and time?**

   Change management processes are in place and correctly adhered to as per the results of the study. There are areas that can be improved on particularly when changes are safety related and needs immediate implementation. Further to this, transparency of budget allocation can be improved on to assist the site based employees to make informed decisions.

5.6.3 Meeting the Research objectives

The main objective of the research is to find out how inconsistent construction methodologies contribute to the majority of the major projects failing and resulting in time and cost overruns. The study has achieved the research objective as highlighted in 5.6.2 above and recommendations brought to the fore for future considerations.

5.6.4 Meeting the Sub Objectives

- The sub-objectives to support the main objectives are summarised as follows:

To evaluate the causes of prolonged construction methodologies on site

- Multiple causes have been identified in the course of the study with the main ones summarized in table 11, 12 and 13.

To evaluate the impact of project upfront activities on construction commencement

- Upfront activities which includes constructs 1 and 3 mainly do have a contribution to the schedule and cost impact
- Cost implications associated with these are captured in table 2 of the report

To enumerate the effects of time and cost of prolonged construction

- Table 11, 12 and 13 elaborates on the aspects captured during the study and shows which ones attracts cost or time and in some instances both.

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